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Daiï

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Introduction

Alphabets are sets of letters used to write words in a language. The usage of a common alphabet forms different languages into a cluster, which helps the transfer of vocabulary between them. European languages, for example, form such a group through the use of the roman alphabet. Languages which use different alphabets can form a cluster if there exists a one-to-one mapping among the latter. The Devanagari alphabet used for Sanskrit and Pali, for instance, already has this kind of mapping since colonial time. The Sanskrit-Pinyin-Tiyapan (SPT) system introduced by K Tiyapan (2003) † binds Daiï with those languages that use the roman alphabet.

Language represents communication, and literature culture. Both provide an identity for a group of people who have them in common. Whereas it is important to have an official language in common, a good example of which is English, it is equally important to keep the local identities in the form of languages and cultures. The best way for two different cultures to communicate, for instance to share ideas and vocabulary in literature, while at the same time retain local identity and flavour, is through the use of a common alphabet the best candidate of which is obviously the roman alphabet.

This is the rationale behind this an other SPT projects. The reason is not difficult to see. Imagine that one wants to discuss literature from Burmese, Chinese, Greek, Hebrew, Hindi, Japanese, Pali, Sanskrit and Daiï sources in one essay, having copious words of each of these languages mentioned. It would be awkward and difficult, if not indeed totally impossible, to do so with all the national alphabets involved, in this case eight of them. Writing all the words approximately in roman letters, and include their precise version in the original scripts between brackets, may provide a graceful solution which works, but could be neither optimal nor satisfactory at best, or leave us in technically a coding chaos at worst. Not optimal, because the approximate words in roman letters and the same word written in the original script necessarily contain certain information which is mutual to both, and

† Kit Tiyapan, *Thai grammar, poetry and dictionary*, Kittix, Bangkok, 2003

therefore not the best, economic use of resource. Not satisfactory, since all the various scripts juxtaposed among one another within a single essay would not have a good, aesthetic look. Moreover, it is a very tall order to expect the readers to be able to make full use of all the scripts present, and what is of no use is only a waste. Lastly, the codings of the various scripts follow certain standards, and standards are various even for each, so the codings involved is a chaos and problem.

It is much more difficult to design such a one-to-one mapping for languages that use pictorial scripts, for example Chinese. This project aims at solving various issues involved in such a design. The aim is to invent a practical one-to-one mapping between Chinese characters and roman letters. The work to be done is to analyse all the pictorial parts used to compose all the characters in Chinese, and then find the best way to represent these using letters of the roman alphabet. The next step is to study the various dialects of the language, then test integrate their vocabulary with the above results. Another task is to compile a dictionary for each dialect, while at the same time test the alphabets in both prose and verse.

The history of romanisation of Chinese, for instance, began with works by Matteo Ricci (1552–1610) and Nicolas Trigault (1577–1628). In his book *Teach yourself Chinese* Thomas F Wade (1818–95) in 1867 used a system of romanisation adapted from the system introduced by R Morrison in 1815. H A giles modified Wade's system and used it in his *Chinese English Dictionary* in 1860. Other systems include the Yale system, which was completed in 1948. None of these systems is isomorphic, that is a one-to-one mapping with the Chinese characters, since they could transliterate only the sounds but not the pictures.

This work is important for my larger project, which is to find a roman-alphabet isomorphism for each and every language of the world, or at least as many languages as possible. This would be valuable in numerous places, for instance for the integration of literature of different languages, and for the future of the world which relies more and more on computer and communication.. Such isomorphism could replace the various coding standards for an alphabet or a set of characters.

Regarding publication of the results, each of the dialects considered should have at least one article written up and submitted to an international journal. Apart from this, there would be a report describing the whole work, as well as possibly some books written and published. The basis for the evaluation of this project would be the assessment of the report and books, and also whether the papers sub-

mitted to the journals are successful. Results are to be disseminated through books, technical papers, and where possible the Internet.

Daiï is a language of the Tai family within a larger group of language designated as Kadai or Kam-Tai. It is arguably the best known of the family and has the greatest number of users. Historically speaking, King Ramkhamhaeng (*Ṛamgamhạeng*, 1275–1317) of the Sukhothai (*Sukhọdaï*) empire created and recorded the first known Thai script. Ayudhàyạ period (1350–1767) saw the entrance of a large number of words from Pali and especially Sanskrit into the Thai lexicon. Also many loan words entered from Khmer during this period which play an important part in both the administrative as well as the royal vocabularies.

Readers who are familiar with Latin, Greek, or modern European languages may find some surprises learning Daiï when they recognise words which look similar to those of the languages they know. Much of Daiï vocabulary comes from Sanskrit and Pali, and these two languages as well as Greek and Latin are languages in the Indo-European family. Thus the Daiï word *nạvị* is the same as the Latin word *nå.vis* and the English word *navy*.

Historically speaking romanisation of the Thai alphabet has been a subject of silent controversy and hushed up ideas. But with the advent of computer and Internet a language like Daiï can no longer afford to be friendly to neither one of these. As John S Quarterman mentioned in his book *The Matrix* (1990),

> The Thai language is not written with the Latin alphabet but with a character set that uses several layers of accent marks. It is very difficult to represent adequately on line-oriented terminals. This may be one reason for the lack of development of computing in a country of 60 million people (compared to 15 million in Australia). There was only one undergraduate computer science programme in the country by the end of 1988, and its first class was scheduled to graduate in 1989.

I was among those in that first computer science programme he mentioned. That was at the Ṛamgaṃhaeng University, which began its B.Sc. in computer science in 1985. Scheduled to graduate in 1989 together with the rest of the class, I completed the course instead in 1992. Only approximately ten per cent of the number of students originally enrolled made it to the end.

The system of writing used in this book represents my own work towards the solution of writing Daiï using the twenty-six roman alphabets. Towards that end, I hope that this system will prove itself useful, at least in an academic setting where it is always desirable to learn more about relationship among different languages, and where a transcription system which provides a one-to-one mapping with the original script is always welcome.

The acronyms used here are: *abrv*, abbreviation; *adj*, adjective; *adv*, adverb; *conj*, conjunction; *derog*, derogatory; *etc*, et cetera; *expr*, expression; *fam.*, family; *fig*, figurative; *gen.*, genus; *i.e.*, id est; *Lan.*, Lanna; *lit*, literary; *Pa.*, Pali; *phon.*, phonetics; *prp*, preposition; *prf*, prefix; *rhym.*, rhymic; *Sk.*, Sanskrit; *sfx*, suffix; *tax.*, taxology and *v*, verb.

Jargons for the scientic names of plants and animals are the following. Phylum is caṃboak, class jān, order anḱaḅ, family vongśxa, genus sȧkul and species jȧniḱ.

The *r han* is represented here sometimes as *˜anr* and as *˜arr* at others. I began by using the former during mid-2002 and then turn towards the latter by and by. Intentionally I leave both here instead of changing the first- to the second form because they are equally appealing, and there are no ambiguities besides.

The Daiï Writing System

§ Daiï alphabet

The romanised system for the Daiï alphabet proposed here is adapted from existing widely accepted standards in other languages. The consonant part is adopted from Sanskrit and Pali, both of which have strong influence on Thai vocabularies. The only differences are the replacement of $\underline{n}$ by *ng* and *ñ* by $\underline{y}$ when it is a c_1. The character *ñ* remains *ñ* when it appears as a c_2. This is in order to leave room above to accommodate tonal marks (varrṇayukṫ) and the silent symbol (*kaṛanṫa*). The only exception to this is the *ś* remained from Sanskrit. The tonal symbols are adapted from the *Pīnyīn* system of China for its simplicity and aesthetic value.

The system presented in this book follows closely works by Tiyapan (2003). But whereas there the main purpose is to design a romanised system which can be one-to-one mapped to the Thai alphabet, here our purpose is to have a reversible mapping. We assume the authenticity of Modern Thai morphology and make the new system a romanised

support of it. We presume in our part no authorities in changing the direction of Daiï grammar. Such authority is already well looked after by Raj̀aḅaṇḍitàyàsthaṇ. We merely concern ourselves with making a romanised support of whatever the *raj̀aḅaṇḍit*'s ('royal scholars') may say about the Daiï language, such support as to us is important for the computer and computing communities.

From the pali,

k	kh	g	gh	ṅ
c	ch	j	jh	ñ
t	th	d	dh	n
ṭ	ṭh	ḍ	ḍh	ṇ
p	ph	b	bh	m

comes the following Table 1 which contains the equivalence of it in Thai called *B̀eṇcāvarrg* or 'the five groups'.

varrg ka	ka	kha	ga	gha	nga
varrg ca	ca	cha	ja	jha	ẏa
varrg ta	ta	tha	da	dha	ṅa
varrg ṭa	ṭa	ṭha	ḍa	ḍha	ṇa
varrg pa	pa	pha	ba	bha	ma

Table 1 *B̀eṇcāvarrg*

which is read with the vowel *a* according to pali.

The names of characters in the Daiï alphabet, however, are read invariably instead with an added vowel *au*. This is generally the case, not only with the name of characters, for example the name *Arjuna* in *Bhagavad Gītå.* is read *Aurāj̀un*. Notice also the the disappearance of the last vowel, which is also usual. The ordering of characters largely follows that of pali, with a few more characters native to Daiï added now and again. There are 44 characters in the Daiï alphabet, 42 of which are now still in use. The complete picture is the following.

k	kh	ḳh	g	g̣	gh	ng				
c	ch	j	z	jh	y	ḍ́				
ṭ	ṭh	ḍh	ḍ	ṇ	ḍ́					
t	th	d	dh	n	ḅ					
p	ph	fh	b	f	bh	m				
y	r	l	v	ś	ṣ	s	h	ḷ	(w,-)	ḥ

These are read as:

kảu kăi (rooster),
khảu khăi (egg),
ḳhảu ḳhoaḰ (bottle, nowadays use *khoaḰ*, *ḳh* being no longer in use),
gảu gvạ̈ï (buffalo),
gảu gọn (human, nowadays use *gon* instead),
ghảu raghang (gong),
ngảu ngụ (serpent),
cảu cạn (plate),
chảu chĭng (cymbal),
jảu jậng (elephant),
zảu zộ (chain),
jhảu krajhọe (*krajhọe* tree),
ỵảu phù ỵhing (woman), ḍảu jaḰḍạ (headdress or crown for male dancer), ṭảu paṭak (staff with a pointed metallic end), ṭhảu ṭhạn (raised supporting base), ḍảu nang moṇḍọ (a female character in *bra abhaïmaṇị*), ḍhảu phùḍhào (an elderly), ḰảuḰek (child),
tảu tăo (turtle),
thảu thung ((ruck)sack),
dảu dahạr (soldier),
dhảu dhong (flag),
nảu nhụ (mouse),
bảu bạimāi (a plant's leaf),
pảu plạ (fish),
phảu phùeng (bee),
fhảu fhạ (wall partition),
bảu bạn (high tray),
fảu fan (tooth),
bhảu saṃbhao (a junk),
mảu mậ (horse),
yảu yakṣa (troll),
rảu rụa (boat),
lảu ling (ape),
vảu vhạen (a ring),
śảu śạlạ (roofed resting place),
ṣảu ṛueṣị (hermit),
sảu sụa (tiger),
hảu hịḅ (chest,box),
ḷảu cuḷạ (*cuḷạ* kite),
(w)ảu ăng (tub),
ḥảu nokḥụk (owl)

the meanings in the bracket being those of second words.

The phonemic character *ṛ* from Sanskrit appears here in two forms as *ṛue* and *ṛụe* respectively for short and long vowels. Similarly the other phonemic character *ĺ* is written as *ĺue* and *ĺụe*. Although the latter one is no longer in use nowadays, one still finds it in older literature, for example *ĺụejạ*, which is now written as *lụejạ* (renowned).

The English character *q* can be used to represent a dot underneath when writing with only ASCII characters, as is the case when writing a usual email. Thus *phùḍhào ặn nhangsụe* (an old man reads a book) could become *phuqhdqhaoh aqvn nhangsuqe* in emails. The latter may not look very promising, but apart from being systematic it provides one with a one-to-one mapping of the characters, vowels, as well as the tonal sounds.

Tonal marks on top show only in the cases where they are there if written using the actual Thai characters. The Thai tonal marks, however, are not preserved. Instead, whenever it is written, a Daiï tonal mark would follow the actual tone no matter which of the Thai tonal mark is used in the original. The reason is that even though the Thai tonal marks may seem obvious to a Daiï despite their not always representing the same tone in every case, they are much less so even to a Daiï when written using a non-Thai script as this.. For simplicity and economic reasons I decided to keep the sounds rather than the symbols, and to show them only in cases where tonal marks actually appear in the Thai writing.

The tonal marks used here are

kạ, kặ, kà, kā́, ká

When one has to write something in Daiï in emails where only ASCII characters count, this could become

```
kaq, kaqv, kaqh, kaqf, kaqz
```

Whenever one needs to use it, *q* is always read as a dot and never as a letter. The reason that this produces no ambiguity is that *v* never occur as a final character, because then it becomes *w*, neither do *h*, *f* and *z*.

The shape of the letter *v* resembles that of the tonal mark it represents. In the case of *h* similar resemblance may be seen in the slanted

top of the letter 'h', in case of *f* the crossing line on the middle of the character and in case of *z* the sloping part of the character.

The letter *w* has two usages here. It can either acts as a silent *h* when precedes a vowel which begins a new syllable that occurs in the middle of a word, or it can mean the consonant *v* when the latter acts as a final consonant of a syllable. When *w* represents a silent vowel symbol *h*, it can be thought of as being a Greek ω. It is to be used in place of a diaeresis, the latter being not applicable because of the need to leave room above the vowel free for the accommodation of possible tone marks.

The letter *x* can be used in place of a dot placed above a consonant to represent a *kạranŧa* or *daṇḍaghạt*, when written in emails. In effect, it means that the vowel which directly follows the consonant underneath it is not to be pronounced. It is also used in cases where one wants to avoid putting a dot above a letter which has already got another accent on top, for example *d́* as in *śakd́xi* which is often found as a suffix in first names. When placed on top of a vowel, it means that there is the vowel must be read, but is not shown there when written in Thai script.

The dot underneath which helps increasing the amount of existing Roman characters, as well as showing the lengthening of the sound when written under a vowel, can be written as the letter *q* following the character it used to go underneath, as the example above has shown. Another approach to represent this dot could be to use *q* after all consonants which used to have a dot underneath, but simply replace a dotted vowel by doubling the letter which used to have the dot underneath.

Combined characters are made by putting two characters together with no vowel in between. Leading consonants put together this way are said to be *goaḅklàṃ*, that is 'sound together'. The possibilities are, for low characters *gl, gr, gv, pl, pr*, for middle characters *kl, kr, kv, pl, pr, tr*, and for high characters *khl, khr, khv, phl, phr*.

Each of these character groups is considered as a single unit and move around together. Therefore the word for 'far' is written as *klai* instead of as *kail*, because *kl* is a single unit and *l* is not a final consonant. Having mentioned 'far' it is interesting to note that the word with an opposite meaning to it is *klài*, which is only a single tone mark or two tone sounds away.

Other consonant combinations are pronounced as a single charac-

ter, *dr* as *z*, *sr, śr* as *s*, *cr* as *c*. However, consonants which are not meant to be voiced together as one consonant may sometimes be found adjacent to each other without a vowel in between. This only happens with Thai vowels which are written in front of the leading character of the syllable. These vowels are namely *e, ẹ, ae, ạe, o, ọ, ai*, and *aị*. For such vowels, one syllable can sometimes precede the leading consonant of another syllable which goes before it and which contains an unwritten short *a*. In any one of these cases there are three possible ways to write a word, including one where the *a* vowel is written. Therefore consider only one example of word using an *ạe* vowel, *sd́ạeng*, which means 'demonstrate' or 'exhibit'. Here *s* and *d́* do not share a vowel, as the case must be with two characters which are said to be together. In fact the former has got a vowel of its own which is not written, and it would have been possible in theory to write *sa̲d́ạeng* or *sad́ạeng*, both of which would have sounded exactly the same as the word in question though none such words exist in the Thai lexicon in this case.

The repeat symbol, *māiya̲mok*, is replaced by doubling the word concerned and putting between them a dash. Hence *pàṃ-pàṃ pǫ́e-pǫ́e*, 'forgetful' or 'lapse-some'. This, in ASCII only, would become `pamqh-pamqh poqez-poqez`. Here *h* and *z* are tonal symbols, and *q* is an underdot, so we repeat the first letter to the right of the ending of each syllable to be repeated.

The special vowel unit called *ra̲u han*, which has an origin in Sanskrit, is written as *–arr*. Thus *ḅarrdao*, 'to alleviate'; *dharrm*, 'dhamma' or 'the teaching of the Buddha'; *dharrma̲d́ạ*, 'normal'; *mài dharrma̲d́ạ*, 'extraordinary'.

Regarding the various symbol used in Thai script, though of no great concern to us here, it may be worthwhile to mention briefly about the position they take relative to one another as well as relative to the leading and the final consonants. Final consonants post no trouble as they always appear at the rightmost end of a syllable.

We may designate the various positions relative to the leading consonant, namely 'south, west, north, north of north, east', and 'east of east', represented by S, W, N, NN, E, and EE respectively. The S group comprises of *sa̲ra u* and *sa̲ra ụ*; the W group *sa̲ra ẹ, sa̲ra ạe, sa̲ra ọ, sa̲ra ai*, and *sa̲ra aị*; the N group *sa̲ra i, sa̲ra ị* and *māi han ạkạś*; the NN group *māi ẹk, māi dọ, māi trị, māi cata̲vạ*, and *māi tăigū*; the E group the two assisting characters *ya̲u yaks̲a* and *va̲u vhạen*; and finally the EE group *sa̲ra a* and *sa̲ra ạ*.

§ **Syllabic formation**

In Modern Thai alphabet each syllable may form thus,

$$\begin{array}{ccccc} & & h & & \\ & & u_3 & & \\ v_1 & c_1 & v_2 & c_2 & \\ & & v_4 & & \end{array}$$

where c_1 and c_2 are respectively the initial and the final consonants, v_1, v_2, v_3 and v_4 are those parts of vowel put in front, after, above and respectively below c_1, and h is the thing you put on top of everything, which can be either a tone indicator or a *karanta*.

On the other hand, in our SPT Daiï we recognise the following syllabic formation,

$$\begin{array}{ccc} & u & \\ c_1 & v & c_2 \\ & l & \end{array}$$

where c_1 and c_2 remain the initial and the final consonants as in the previous case, v is the vowel, u anything put above the vowel and l anything below the same.

§ **Metamorphosis of consonant**

In order to render the reading of word easier, and also because it does not affect the reversability requirement, some consonants metamorphose when they function as c_2. Table 2 gives all the consonant metamorphoses in Daiï.

Initial (c_1) *Consonant*	*Final* (c_2) *Consonant*
K	k
Kh	kh
Ḳh	ḳh
Ġ	g
Ġ	ġ
Gh	gh
Ng	ng
C	c
Ch	ch
J	j
Z	z
Jh	jh
Ẏ	ñ
Ḍ	ḍ
Ṭ	ṭ
Ṭh	ṭh
Ḍ	ḍ
Ḍh	ḍh
Ṅ	ṅ
Ḍ́	ḍ́
T	t
Th	th
D	d
Dh	dh
N	n
Ḅ	ḅ
P	p
Ph	ph
Fh	fh
B	b
F	f
Bh	bh
M	m
Y	ï
R	r
L	l
V	ö, ü
Ś	ś
Ṣ	ṣ
S	s
H	
Ḷ	ḷ
(A)	
Ḥ	

Table 2 *Consonant metamorphoses*

§ **Example**

In order to give some examples to show the usefulness of the present system of writing, I would like to draw on a few classical examples. The following examples are real and not so easy to deal with. I hope to show that it is possible to write them in Roman characters. Ultimately by replacing lower dots with [q]'s, upper dots with *x*, and tonal marks with *v, h, f*, and *z*, one may translate them into wholly ASCII characters for emailing on standard mailing system without too much difficulty. Once one has become used to reading under these convention, it will be an easy matter to communicate exact meaning by them.

The following is a poem called *K̲au Kạ*, *k̲au* being the name of the first Daiï character and *kạ* means 'a crow'. It is a fine piece of work and has obtained a classic status it deserves. One of the reasons, if not the only one, that I write this book is in order to be able to translate something like this. As you will probably see, it is quite impossible to do so without some means of writing Daiï words in Roman characters, which necessarily have got to be accurate, in other words provide a one-to-one mapping, while at the same time look natural enough to go along smoothly with the rest of the texts. I hope I have not been totally unsuccessful in this respect.

One may safely assume that every Daiï knows this poem to a greater or lesser extent. In my point of view, if any Daiï immigration officer would like to test whether someone is a Daiï or not, for instance at the border when someone claiming for the reason that he has been robbed of all his belongings would like to enter the country without a passport, then he could simply ask that person to recite to him a part of the *K̲au kạ* and assume that if he could do it then to all intents and purposes he is a Daiï. This is because he will presumably have learnt it at school if he is a Daiï. And only a part, not all, of it because it is unlikely that a typical Daiï will be able to remember all of it in one go. So that if he were to insist on hearing total recollection of it, then the officer himself might find it rather difficult to come across the border.

Kảu óey *k̲au* kăi	Kảu *kăi* a hen
Kh̲au khăi yṷ̌ naị lāo	Khảu *khăi* an egg in the pen
Ḳh̲au ḳhoaḱ khaung rao	Ḳhảu *ḳhoaḱ* a bottle of ours
Ġ̲au gvạï thai nạ	Ġảu *gvạï* a buffalo breaking grounds
Ġ̣̲au ġon khueng khang	Ġảu *ġon* a man who is serious

Gha̲u raghang khậng fhạ — Ghảu *raghang* a bell hanging by the wall

Nga̲u ngụ caị klà — Ngảu *ngụ* a serpent so daring
Ca̲u cạn jaị ḍị — Cảu *cạn* a plate is useful

Cha̲u chĭng tị ḍang — Chảu *chĭng* a cymbal resounds loudly

Ja̲u jậng vìng nhị — Jảu *jậng* an elephant in flight
Za̲u zọ̀ làm dị — Zảu *zọ̀* a chain please help bind it
Jha̲u krajhọe gù kan — with Jhảu *krajhọe* tree

Ẏa̲u phùẏhing sọbhạ — Ẏảu *phùẏhing* a woman so beautiful

Ḍa̲u jảḍạ soamsăị — Ḍảu *ja̲ḍạ* headdress for wearing
Ṭa̲u pảṭak pak vāi — Ṭảu *pa̲ṭak* staff driven in place
Ṭha̲u ṭhạn khào mạ raung — Ṭhảu *ṭhạn*, the supporting base

Ḍa̲u nạng Moṇḍọ nhậ khạö — Ḍảu *nạng Moṇḍọ* lady with white countenance

Ḍha̲u phùḍhào ḍoen yàung — Ḍhảu *phùḍhào* an old man treads carefully

Ṇa̲u ṇẹr mài maung — Ṇảu *ṇẹr* an ordained child looks not

Ḱa̲u ḱek tậng nimonṭa — Ḱảu *ḱek* a boy has to invite him

Ta̲u tăo lhang tung — Tảu *tăo* a turtle, its back a-humped

Tha̲u thung bạek khon — Thảu *thung* a bag for carrying things in

Da̲u dảhạr oḱdon — Dảu *da̲hạr* a soldier with stamina
Dha̲u dhong gon niyom — Dhảu *dhong* a flag is popular
Na̲u nhụ khvakkhvăi — Nảu *nhụ* mice run confusingly around

Ḅa̲u ḅaịmāi taḅthom — Ḅảu *ḅaịmāi*, leaves gather on the ground

Pa̲u plạ tạ klom — Pảu *plạ* a fish has round eyes
Pha̲u phùeng daṃ rang — Phảu *phùeng*, bees build their hive

Fha̲u fhạ dondạn — Fhảu *fhạ* a wall-board is enduring
Ba̲u bạn vạng tàng — Bảu *bạn* a tray standing up
Fa̲u fan sa-ạḱ cang — Fảu *fan*, teeth so very clean

Bha̲u saṃbhao kạng bạị — Bhảu *saṃbhao* a junk in full sail

Ma̲u mậ guekgak — Mảu *mậ* a zestful horse
Ya̲u yakṣa khìaö ẏhăị — Yảu *ya̲kṣa* a big-tusked troll
Ra̲u rụa baï pai — Rảu *rụa* a boat being rowed along
La̲u ling tăi rạö — Lảu *ling* a monkey climbing bars

Va̲u vhạen long yạ — Vảu *vhạen* a tempered ring
Śa̲u śạlạ ngiaḅnghao — Śảu *śạlạ* a deserted shed

Ṣa̲u ṛueṣị nhoaḋ yạö	Ṣảu *ṛueṣị* a long-bearded hermit
Sa̲u sụa ḋạö ganaung	Sảu *sụa* a vigorous leopard
Ha̲u hịḅ săị yạ	Hảu *hịḅ* a medicine chest
Ḷa̲u culạ dạ̀ phảyaung	Ḷảu *culạ*, a proud kite
Ȧu ặng ruangraung	Ȧu *ặng* a bright-shining bowl
Ḥa̲u nokḥụk tạ tọ	Ḥảu*nokḥụk* is an owl with large eyes

In 1782 King Rama I moved the capital of Siam to the present site of Bangkok. The full name of the city is,

krungdẹbma̲ḥạna̲gaur a̲maurrata̲na̲kọsindra̲ mahinda̲raṛayuddha̲yạ ma̲ḥạdilokbhob noba̲rata̲na raja̲dhạnịḅuriromya̲ uḋomraṛaja̲niveśma̲ḥạsa̲thạn a̲maurbimạn a̲vata̲rsa̲thitya̲ sakkadattiyaviṣa̲ṇukarrmprasidd̶hi

which could be translated as,

created by the deed of the divine Visnu and resided in by Narayana, such monumental place and abundant palace and great auspicious abode, the nine precious crystals and lovable capital city, an unassailable god, the immortal heavenly gem, angelic metropolitan city. This is the present name as slightly changed by King Rama IV. The original name begins with *Krundẹbma̲ḥạna̲gaur ḅa̲uvaurrata̲na̲kọsindra̲*..., the rest being the same.

Another example is a letter, but which has been sent neither by post nor email.

30^{th} Dhanvạgom 2544
Manchester

Kraḥḍậö guṇbậu guṇmậe dị gaorobrak,

Vannī hima tok mùarhăi màidraḥ. Taun ḋọen aumạ ca pai vậïnāṃ dị *Aquatic Centre* kàụ hen pokglum khạöbloṇ pai mhoḋ lāeö. Dị hạu mị snạm yhà, tặe pen sảnạm yhà diam daṃ ḋòay saṛsanggrauha glậï-glậï brom pụ ḅon kroaḋ la-iaḋ zùeng yŭ ḅon kàunfọm yhăị ịkdị. Snạmyhà diam kàụ thụk hima glum mhoḋ mhuankan, ḋụ soaïḋị. Dị ḅon lhanggạ *Town Hall* mị *Santa Claus* kau yŭ, phlŏ tặe sŏanḅon tặe mài draḥ daṃmai. naị mụe thụe *space shuttle* yŭ laṃ nueng.

Rak lae gaorob yặngsụng,
Nhŭï

30^{th} December 2001
Manchester

Dear mother and father,

I don't know when snow fell today. Everywhere was already covered in white when I was walking to the Aquatic Centre to swim. At the dorm there is a grass lawn, but it is made of synthetic material very much like carpet, which lies on fine gravels on top of some huge foam chunks. The synthetic lawn is also covered in snow and looks lovely. At the Town Hall there is a Santa Claus perching there on top of the roof, with only the upper part visible. But I don't know why he is holding a space shuttle in one hand.

Lots of love,
Kit

In an email with no facility to accommodate Thai characters, this letter could take one of the many forms possible depending on how one may choose to replace all the various dots and tone symbols. My preference is for some way of writing which incorporates no extra special symbols, and my solution is the following. I hope you have not been discouraged by the look of the original version above already.

30^{th} Dhanvaqgom 2544
Manchester

Kraqbqdaqfoe gunqbaquh gunqmaqeh diqh gaorobrak,

Vanniqf hima tok muqahrhaiv maihdraqbq. Taun dzoqen aumaq ca pai vaqhienamqf diqh *Aquatic Centre* kauqh hen pokglum khaqoe-bloqn pai mhodz laefoe. Diqh haqu miq snaqm yqhaqh, taqev pen saxnaqm yqhaqh diam damq dzoahï saqrsanggrauhxa glaqfie-glaqfie brom puq bqon kroadz la-iadz zuehng yuqv bqon kauhn-foqm yqhaiqv iqkdiq. Snaqmyqhaqh diam kauqh thuqk hima glum mhodz mhuankan, dzuq soaiedziq. Diqh bqon lhanggaq *Town Hall* miq *Santa Claus* kau yuqv, phloqv taqev soavnbqon taqev maih draqbq damqmai naiq muqe thuqe *space shuttle* yuqv lamq nueng.

Rak lae gaorob yaqvngsuqng,
Nhuvie

A constraint like this, *i.e.* limiting oneself to using only ASCII characters, may seem severe, but it introduces the stretch necessary in order

to test the robustness of a design. The reason I write the long *ạ* vowel by *aq* instead of a seemingly simpler *aa* is in order that *q* may always stand for, and read as, a dot which goes under any character in front of it. And the reason that a dot is needed below a vowel instead of above it as an indication that it is a long vowel is, in order that the space above the vowel may be left free to accommodate the tone marks.

Both *ai* and *aị* sound exactly the same but the latter is rarer. In fact the number of all words written with *aị* amounts to only twenty in total. The following example gives the exhaustive list of them in a mnemonic poetical form which every Daiï knows by heart.

Phùyhăị̆y hạ phạ̀ mhăị	A grown-up sought new cloth
hàị sabhāị jāị glāung gạu.	for his daughter-in-law to put on her neck.
Fhăị̆caị ao săị hặ̆u	Take care to put it in a wrapping,
mi lhonglhaị glaị khạu ḍ́ụ.	never ever forget who asked to have a look.
Ca gràị long rụaḅaị	Wish to get on a sailing boat,
ḍ́ụ nām̱ saị lae plạ pụ.	view the clear water and those small creatures under water.
Sĭngḍ́aị yŭ̱ naị tù	Whatever is inside a cabinet
mijàị yŭ̱ tàị tăng tiang.	is never under another piece of furniture.
Ḅàḅàị thụe yaị̆ḅọa	The deaf and dumb holds a lotus stalk,
hụtạ mọa mạ klàị̆giang.	approaches with his glazed eyes.
Rèng dàung yặ̆ lalìang	Recite you without fail
yị̀siḅ mọ̄an caṃ cong ḍ́ị.	and remember well the twenty curls.

The word 'curls' which occurs in the last stanza above alludes to the 'curl symbols' which is what the name of the symbol *māimọ̄an* used for the vowel *aị* means.

The following example is to show the transposition of meaning through the process of translation. First a song by Elvis Prestley is translated into Daiï. Then the Daiï version thus obtained is translated back into English. What I wish to show is the unavoidable changes inherent in a process of translation which makes it necessary to reduce the number of intermediate steps to the minimum when translating, which is the reason why one should always try to translate only texts in their original languages. Therefore translating something which is

originally written in French, from its English version is by no means a wise thing to do.

'It's now or never come hold me tight.
Kiss me my darling, be mine tonight.
Tomorrow will be too late.
Kiss me my darling, my heart wouldn't wait.'

Which is translated into the following.

Mài taunnī kạu màitàung mạ kauḱ chan.
Cụḅ chan si dịrak, hài chan gụennī.
Brùngnī kàụ ca dureś pai.
Cụḅ chan si dịrak, caị chan mài gauï.

Which is then translated into English without comparing with the original.

'If not now, then don't come embrace me.
Come kiss me my dear, sleep with me tonight.
Tomorrow will be too absurd.
Come kiss me my dear, I shall not wait.

This example may seem somewhat exaggerated, but not so much so I believe because of the constraint I have applied with regard to the number of syllables in each phrase have made it necessary to look for equivalence instead of writing out a lengthy description. This constraint is, I think, justified and must not be taken too lightly when translating songs and poems.

Grammar

Daiï has 32 vowels, namely a, ạ, i, ị, ue, ụe, u, ụ, e, ẹ, ae, ạe, o, ọ, au, ạu, oe, ọe, ia, ịa, ua, ụa, oa, ọa, ṛue, ṛụe, Íue, Íụe, aṃ, aị and ao.

Unless indicated by other vowels, all Daiï consonants have an inherent '-ạu', for example *k* is read *kạu* except when it has some other vowels when it becomes ka, kạ, ki, kị, kue, kụe, ku, kụ, ke, kẹ, kae, kạe, ko, kọ, kau, kạu, koe, kọe, kia, kịa, kua, kụa, koa, kọa, kṛue, kṛụe, kĺue, kĺụe, kaṃ, kaị, kai and kao.

There are 44 consonants, namely k, kh, ḳh, g, g̣, gh, ng; c, ch, j, z, jh, y; ḍ́, ṭ, ṭh, ḍ, ḍh, ṇ; d́, t, th, d, dh, n; ḅ, p, ph, fh, b, bh, m; y, r, l, v, ś, ṣ, s, h, ḷ, w, and ḥ.

Daiï consonants are divided into three groups, namely *middle, high* and *low* consonants, according to whether the tonal sound of their phonemes with long vowels is the first (neutral) or the fifth (high) tone.

Middle consonants are *ḅ, c, d́, ḍ́, k, p, w, t, ṭ*. High consonants are *ch, fh, h, kh, ph, s, ṣ, ś, th, ṭh*. Low consonants are *b, bh, d, dh, ḍ, ḍh, f, g, g̣, ḥ, j, jh, z*. The rest of the consonants, namely *l, ḷ, m, n, ṇ, ng, r, v, y, ẏ* are called *sonorants*. They all have low tone which become high when combined with *h* to form *lh, mh, nh, ngh, vh, yh, ẏh*.

Consonants together with their comparative sound in English given in brackets are: b (p), ḅ (b), c (j, as in *jar*), ch (ch), d (t), ḍ (t), d́ (d), dh (t), ḍh (t), f (f), fh (f), g (k), g̣ (k), gh (k), h (h), ḥ (h), j (ch), k (k), kh (k), l (l), ḷ (l), m (m), n (n), ṇ (n), p (p), r (r), s (s), t (t), ṭ (t), th (t), ṭh (t), v (w), , y (y), ẏ (y), z (s).

When in the initial position, they have these sounds. But when in a final position, they are grouped together into eight groups, namely *kok, kod́, koḅ, kong, kon, kom, kọey*, and *kọew*, which respective sound as *k, d́, ḅ, ng, n, m, y*, and *w*.

The *kok* group comprises of *g, g̣, gh, k, kh*; the *kod́* group *c, ch, d, ḍ, d́, dh, ḍh, ḍ́, j, t, ṭ, th, ṭh*; the *koḅ* group *p, ḅ, f, fh, p*; the *kong* group contains only one, that is *ng* itself; the *kon* group contains *n, ṇ, ẏ*; the *kom* group *m*; the *kọeï* group *ï*; and finally the *kọeö* group has *ö*. The *kok*, *kod́* and *koḅ* groups are called *dead* groups, while the remaining are called *live* groups. It is interesting to note that *ï* is in the *kọeï* group while *ñ* in the *kon* group.

§ **Ending consonant**

Referring to Table 2, Table 3 gives all the consonants together with their sounds when appearing at the beginning and when at the end of a syllable.

Beginning(c_1)		*Ending*(c_2)	
Consonant	*Sound*	*Consonant*	*Sound*
K	‘g’ in ‘god’	k	‘k’
Kh	‘c’ in ‘country’	kh	‘k’
Ḳh	‘c’ in ‘can’	ḳh	(obsolete)
Ġ	‘k’ in ‘Kent’	ġ	‘k’
Ġ	‘c’ in ‘coast’	ġ	(obsolete)
Gh	‘K’ in ‘Kuwait’	ġh	‘k’
Ng	‘ng’ in ‘kissing’	ng	‘ng’
C	‘j’ in ‘Japan’	c	‘d’
Ch	‘ch’ in ‘China’	ch	(not used)
J	‘ch’ in ‘chop’	j	‘d’
Z	‘s’ in ‘so’	z	‘d’
Jh	‘ch’ in ‘chain’	jh	(not used)
Ẏ	‘y’ in ‘Yen’	ñ	‘n’
Ḍ́	‘d’ in ‘dog’	ḍ́	‘d’
Ṭ	‘t’ in ‘stand’	ṭ	‘d’
Ṭh	‘t’ in ‘tempt’	ṭh	‘d’
Ḍ	‘t’ in ‘time’	ḍ	‘d’
Ḍh	‘th’ in ‘Thames’	ḍh	‘d’
Ṇ	‘n’ in ‘no’	ṇ	‘n’
Ḍ́	‘d’ in ‘dream’	ḍ́	‘d’
T	‘t’ in ‘getting’	t	‘d’
Th	‘t’ in ‘tin’	th	‘d’
D	‘t’ in ‘to’	d	‘d’
Dh	‘t’ in ‘Tim’	dh	‘d’
N	‘n’ in ‘new’	n	‘n’
Ḅ	‘b’ in ‘big’	ḅ	‘b’
Ṗ	‘p’ in ‘Sapporo’	p	‘b’
Ph	‘p’ in ‘pen’	ph	(not used)
Fh	‘f’ in ‘fire’	fh	(not used)
B	‘p’ in ‘pack’	b	‘b’
F	‘f’ in ‘fang’	f	‘b’
Bh	‘p’ in ‘put’	bh	‘b’
M	‘m’ in ‘miss’	m	‘m’
Y	‘y’ in ‘you’	ï	
R	‘r’ in ‘rock’	r	‘n’
L	‘l’ in ‘look’	l	‘n’
V	‘w’ in ‘wood’	ö, ü	
Ś	‘s’ in ‘send’	ś	‘d’
Ṣ	‘s’ in ‘sit’	ṣ	‘d’
Ṡ	‘s’ in ‘sell’	s	‘d’
H	‘h’ in ‘hen’		
Ḷ	‘l’ in ‘list’	ḷ	‘n’
(A)	(used for vowels)		
Ḥ	‘h’ in ‘hit’		
Ṁ		ṁ	‘m’ or ‘ng’

Table 3 *Initial and ending consonants together with their sounds*

*Rassa̲ra*s are short vowels, that is to say, a, i, ue, u, e, ae, o, au, oe, ia, ua, oa, ṛue, Íue, aṃ, aị, ai, and ao. The rest of the vowels are *Dịgha̲sa̲ra*s or long vowels, that is ạ, ị, ụe, ụ, ẹ, ạe, ọ, ạu, ọe, ịa, ụa, ọa, ṛụe, and Íụe.

*La̲hu*s are soft vowels. These are all Rassảras that have no final consonants, except aṃ, aị, ai, and ao. *Gru*s are all Dịghảsảras together with these four vowels. In other words with the exception of the four vowels mentioned all long vowels, that is those which have a dot underneath, are Dịghảsảra and Gru. The four vowels, aṃ, aị, ai and ao, are Rassảra and Gru. With a final consonant, all Rassảras become Gru.

Consonants have various bases and characteristics. Table 4 gives a summary of these. All the consonants listed in this table are mụgas. The varrgs are grouped in order moving outwards from the velar to the lips.

		a̲ghọṣa		*ghọṣa*		
		sithil	*dha̲nit*	*sithil*	*dha̲nit*	*sithil*
	kaṇṭha̲ja	k	kh, ḳh	g, g̣	gh	ng
	tạluja	c	ch	j, z	jh	y
mụga	*muddha̲ja*	ḍ́, ṭ	ṭh	ḍ	ḍh	ṇ
	danta̲ja	d́, t	th	d	dh	n
	ọṭṭha̲ja	ḅ, p	ph, fh	b, f	bh	m

Table 4 *Consonants, their bases and characteristics*

Notice that the categorisation of Table 4 is only grammatical one. Daiï morphology follows that of Sanskrit and Pali. But the sounds available in Daiï may not support completely all bases of the *varrg*'s. For example none of the *muddha̲ja* consonants are pronouncable in Daiï, so they are in practice pronounced exactly the same as though they are *danta̲ja*.

As for the rest of the consonants, they are listed together in Table 5 with descriptions given below. The consonants y, r, l and v are arrdhảsảras while ś, ṣ and s are usums.

		plosive				*nasal*
		a̲ghoṣa		*ghoṣa*		
		sithil	*dha̲nit*	*sithil*	*dha̲nit*	*sithil*
	kaṇṭha̲ja	(w)	h	ḥ		
	taḷuja	ś		y		
muga	*muddha̲ja*	ṣ		r, ḷ		
	danta̲ja	s		l		
	oṭṭhja			v		

Table 5 *Avarrg consonants*

The terms used above together with the equivalent English jargons and explanations are given in Table 6.

Term	*Equivalent term in English*
Ȧghoṣa	voiceless, uttered without vibrating vocal cords
arrdhȧsȧra	semivowel, has the character of both vowel and consonant
dantȧja	dental, pronounced with tip of the tongue against the front upper teeth
dhȧnit	aspirated, pronounced with a breathing
ghoṣa	voiced, uttered with vibrating vocal cords
kaṇṭhȧja	velar, produced by contact with the velum or soft palate
muddhȧja	retroflex, tip of the tongue curved up to touch the front part of the palate, the cavity inside the mouth increases to become slightly hollowed
muga	[pure consonant], has no sounds unless a vowel is added
oṭṭhȧja	labial, sound made by the lips
sithil	unaspirated, pronounced without a breathing
taḷuja	pre-palatal, the tongue touches the palate before making a sound
usum	sibilant, uttered with a hissing sound

Table 6 *Jargons and their English equivalence*

Palate is the roof of the mouth. It is divided into the hard palate, which is the bony front part, and the soft palate, which is the fleshy back part. Plosive sounds are produced by abrupt release of stopped breath.

Daiï is influenced by both Pali and Sanskrit, arguably more words in everyday use come from Sanskrit than from Pali, but grammatical

jargons in use are normally Pali. Pali has its hold on the teaching of Daiï grammar through Buddhism and teaching of monks in Buddhist temples. Table ৪ gives the Sanskrit equivalence for those terms mentioned in Table 6. Here 'hard' means 'voiceless' and 'soft' means 'voiced'.

Pali	*Sanskrit*	*Meaning*
Ȧghọṣa	kaṭhora	'hard'
dantȧja	dantya	'tooth'
ghọṣa	mṛdu	'soft'
kaṇṭhȧja	kaṇṭhya	'throat'
muddhȧja	mūrdhnya	'front palate'
ọṭṭhȧja	oṣṭhya	'lips'
tạluja	tå.lavya	'palate'
usum	ūṣman	'steam'

Table 7 *Pali and Sanskrit equivalent terms*

There are eight mạtrạs, categorised by means of the ending consonant. They are kạ, kon, kong, kok, koḋ, koḅ, kom and kọey mạtrạs. These are written together with the vowels as follows.

Mạe kạ

kȧ, kạ, ki, kị, kue, kụe, ku, kụ, ke, kẹ, kae, kạe, ko, kọ, kau, kạu, koe, kọe, kia, kịa, kua, kụa, koa, kọa, kṛue, kṛụe, kĺue, kĺụe, kaṃ, kaị, kai, kao and ka.

Mạe kon

kon, kan, kạn, kin, kịn, kuen, kụen, kun, kụn, ken, kẹn, kaen, kạen, kọn, kaun, kạun, koan, kọan, kian, kịan, kuan, kụan, koen, kọen and koẹn.

Mạe kong

kong, kang, kạng, king, kịng, kueng, kụeng, kung, kụng, keng, kẹng, kaeng, kạeng, kọng, kaung, kạung, koang, kọang, kiang, kịang, kuang, kụang, koeng, kọeng and koẹng.

Mạe kok

kok, kak, kạk, kik, kịk, kuek, kụek, kuk, kụk, kek, kẹk, kaek, kạek, kọk, kauk, kạuk, koak, kọak, kiak, kịak, kuak, kụak, koek, kọek and koẹk.

Mạe kod́

kod́, kad́, kạd́, kid́, kịd́, kued́, kụed́, kud́, kụd́, ked́, kẹd́, kaed́, kạed́, kọd́, kaud́, kạud́, koad́, kọad́, kiad́, kịad́, kuad́, kụad́, koed́, kọed́ and koẹd́.

Mạe kob̩

kob̩, kab̩, kạb̩, kib̩, kịb̩, kueb̩, kụeb̩, kub̩, kụb̩, keb̩, kẹb̩, kaeb̩, kạeb̩, kọb̩, kaub̩, kạub̩, koab̩, kọab̩, kiab̩, kịab̩, kuab̩, kụab̩, koeb̩, kọeb̩ and koẹb̩.

Mạe kom

kom, kam, kạm, kim, kịm, kuem, kụem, kum, kụm, kem, kẹm, kaem, kạem, kọm, kaum, kạum, koam, kọam, kiam, kịam, kuam, kụam, koem, kọem and koẹm.

Mạe kọeï

kọeï, koẹï, kaï, kạï, kạö, kiö, kịö, kueï, kụeï, kuï, kụï, keö, kẹö, kaeö, kạeö, koï, kọï, kauï, kạuï, koaï, kọaï, kiaö, kịaö, kuaï, kụaï and kaiï.

All mạe kạ syllables with a long vowel or a short vowel aṃ, aị, ai, or ao, and in the kon, kong, kom, or kọeï mạtrạ are *gaṃ pen*, that is to say, 'live words'. The rest, that is syllables with the remaining short vowels in the kạ mạtrạ and those in the kok, kod́, or kob̩ mạtrạ are *gaṃtạï* or 'dead word'.

Traiyạngs̩a is the three groups of characters, namely akṣaur sụng or high characters – kh, ḳh, ch, ṭh, th, ph, fh, ś, ṣ, s and h; akṣaur klạng or middle characters – k, c, ḍ́, ṭ, d́, t, b̩, p and w; akṣaur tăṃ or low characters – g, g̣, gh, ng, j, z, jh, y̰, ḍ, ḍh, ṇ, d, dh, n, b, f, bh, m, y, r, l, v, ḷ and ḥ.

The three groups of letters combine with vowels and varrṇȧyukŧas as shown in Table 8 (*cf* Table 10). Table 10 is what I arrived at working in Manchester during 2002 while Table 8 what appears in 'Lhak bhaṣạ Daiï' by Kaṃjay Daunglhặu. The latter is written by an authority and therefore should be more reliable.

	gaṃ pen	*gaṃ tạy*
akṣaur sụng	124	12
akṣaur klạng	01234	1234
akṣaur tặṃ	023	234

Table 8 *Traiyạngṣa in combination with vowels and varrṇ̲ayukŧas*

There were many possible tọahans, for example kakk, khangng, mann, caɗɗ, dhamm, respectively called k-han, ng-han, n-han and ɗ-han. But at present there is only one remaining, the r-han as in *dharrm*.

§ **Vowels**

Table 9 shows the vowel combinations of the present system. Not all the positions in the table are used in Daiï. The rest of the columns other than the first one are only used where tonal symbols are used in actual Thai script.

a	ă	à	ā	á
ạ	ặ	ạ̀	ạ̄	ạ́
i	ĭ	ì	ī	í
ị	ị̆	ị̀	ī	ị́
ue	ŭe	ùe	ūe	úe
ụe	ụ̆e	ụ̀e	ūe	ụ́e
u	ŭ	ù	ū	ú
ụ	ụ̆	ụ̀	ū	ụ́
e	ĕ	è	ē	é
ẹ	ẹ̆	ẹ̀	ē	ẹ́
ae	ăe	àe	āe	áe
ạe	ặe	ạ̀e	ā	ạ́e
o	ŏ	ò	ō	ó
ọ	ọ̆	ọ̀	ō	Ọ́
au	ău	àu	āu	áu
ạu	ặu	ạ̀u	ā	ạ́u
oe	ŏe	òe	ōe	óe
ọe	ọ̆e	ọ̀e	ōe	ọ́e
ia	ĭa	ìa	īa	ía
ịa	ị̆a	ị̀a	īa	ị́a
ua	ŭa	ùa	ūa	úa
ụa	ụ̆a	ụ̀a	ūa	ụ́a
oa	ŏa	òa	ōa	óa
ọa	ọ̆a	ọ̀a	ōa	ọ́a
aṃ	ăṃ	àṃ	āṃ	áṃ
ai	ăi	ài	āi	ái
aị	ăị	àị	āị	áị
ao	ăo	ào	āo	áo

Table 9 *Vowel table*

Daiï vowels with guide for their sounds in brackets are as follows: *a* (‘a’ in ‘anew’),

ạ (‘a’ in ‘far’),

i (‘i’ in ‘fit’),

ị (‘ee’ in ‘bee’),

ue (‘ü’ in ‘München’),

ụe long ‘ü’,

u (‘u’ in ‘put’),

ụ (‘oo’ in ‘food’),

e (‘e’ in ‘sex’),

ẹ (‘a’ in ‘day’),

ae (‘a’ in ‘fab’),

ạe (‘ear’ in ‘bear’),

o short ‘o’,

ọ (‘o’ in ‘go’),

au (‘o’ in ‘cot’),

ạu (‘or’ in ‘Thor’),

oe (‘e’ in ‘cluster’),

ọe (‘u’ in ‘occur’),

ia short,

ịa (‘ear’ in ‘dear’),

ua ‘ue’ + ‘a’,

ụa ‘ụe’ + ‘ạ’,

oa short,

ọa (‘oa’ in ‘Samoa’),

aṃ (‘am’ in ‘Annam’),

ai (‘i’ in ‘vital’),

aị ditto, and

ao (‘ao’ in ‘Tao’)

Here *oa* and *ọa* alone suffice whereas in the actual Thai writing a final *w* would have been written, and similarly *ia* and *ịa* suffice with no need for a final *y*.

Apart from the vowels *ạ, i, ị, u, ụ, ue, ụe, ẹ, ọ*, each of which corresponds to a single vowel symbol of the Thai script, each of the following vowels of the present convention maps into vowel symbols of the conventional Thai script inside round brackets when it has no final consonant, and inside square brackets when it has one:

a (a) [māihan],

e (‘ẹ’, ‘a’) [‘ẹ’, ‘māităigū’],

o (‘ọ’, ‘a’) [–],

ae (‘ạe’, ‘a’) [‘ạe’, ‘māităigū’],

ạe (‘ạe’, ‘ạu’) [‘ạe’],

au (‘ẹ’, ‘ạ’, ‘a’) [*theor* ‘māităigū’, ‘ạu’],

ạu (the free vowel symbol equivalent to *w*, which is written with an alphabet called ‘ạu ặng’ in Daiï) [‘ạu’],

oe (‘ẹ’, ‘ạu’, ‘a’) [‘ẹ’, ‘i’],

ọe (‘ẹ’, ‘ạu’) [‘ẹ’, ‘ạu’],

ia (‘ẹ’, ‘ị’, ‘yảu’, ‘a’) [*theor* ‘ẹ’, ‘ị’, ‘māităigū’],

ịa (‘ẹ’, ‘ị’, ‘yảu’) [‘ẹ’, ‘ị’, ‘yảu’],

ua (‘ẹ’, ‘ụe’, ‘ạu’, ‘a’) [*theor* ‘ẹ’, ‘ụe’, ‘māităigū’, ‘ạu’],

ụa (‘ẹ’, ‘ụe’, ‘ạu’) [‘ẹ’, ‘ụe’, ‘ạu’],

oa (‘māihan’, ‘vảu’, ‘a’) [*theor* ‘māihan’, ‘māităigū’, ‘vảu’],

ọa (‘māihan’, ‘vảu’) [‘vảu’].

Here the Daiï vowel symbol names are shortened, namely ‘ạu’ stands for ‘ạu aặng’, ‘yảu’ for ‘yảu yakṣa’, ‘vảu’ for ‘vảu vhạen’, ‘māihan’ for ‘māihan-ạkạś’, ‘a’ in place of ‘sảra a’, ‘ẹ’ in place of ‘sảra ẹ’, and so on.

Cases with *theor* written are include here only because some authors do use them sometimes in order to deliberately emphasise the shortness of a vowel, even though they may never appear in a dictionary. Though some grammarians completely exclude them, in my point of view they are theoretically correct because in general an ‘a’ symbol may be replaced by a ‘māităigū’ when a final consonant is present. The remaining three vowels, namely *ai*, *aị*, *ao*, which never have final consonants, correspond respectively to (‘māimạlaiï’), (‘māimōan’), (‘ẹ’, ‘ạ’).

I try to follow strictly the spelling of words, and not the actual pronunciation, because in such cases where these two differ from each other one also has to remember anyway even when using Thai script. Example of such words where the two differ are *bẹjr* (‘diamond’) which is written using a long vowel but pronounced as a short vowel (as [‘bed́’] instead of [‘bẹd́’], *j* belonging to the *kod́* final consonant group), *hẹtu* (‘cause’) which is pronounced without the vowel *u* at the end (as [‘hẹd́’] instead of [‘hẹ-tu’], *t* being also in the *kod́* group).

§ **Tones**

It is believed that the progenitor language of Daiï has only three tonal sounds instead of five as presently is the case. They are respective the present *common*, *first* and *second* tonal sounds. The number of tones could have split from three into five sometimes during the Ayuddhayạ period. This could have explained the predominance of the first two tonal marks, and also the reason why they keep shifting to the right hand side nearly half of the time. The convention of what to follow is that the tonal sounds are [*common, first, second, third, fourth*], while the tonal marks are [*none, first, second, third, fourth*].

In the system in use here the tonal marks, when they occur, always give the same sounds of their corresponding position in the sequence. This is different from the system used when writing in Thai alphabet

where both the first and the second tonal marks can sometimes shift one step to the right. This may seem to be a drawback even though it is convenient. But each of the two tonal mark systems is governed by a fixed rule, which makes it possible to reach at one from the other if we know three things, firstly the level or height of the initial alphabet of the syllable considered, secondly whether the vowel of that syllable is long or short, and lastly whether a final alphabet is present and if present whether it is a live one.

If we represent the sound and symbol of tones by integer from zero to four, then the tone table can be written out as Table 10 below.

Initial	*Vowel*		*Live*		*Dead*	
alphabet	*Long*	*Short*	*Long*	*Short*	*Long*	*Short*
low	023	23	023	023	23	3
middle	01234	123	01234	01234	123	13
high	124	1	124	124	1	1

Table 10 *Tone table*

From this table, one can see that middle alphabet are richest in tones. Moreover the low and the high initial characters when put together will yield something which covers all the tonal sounds of the middle characters. Indeed it turns out that they combine nicely into the following fifteen pairs, $(g, gh-kh)$, $(j, jh-ch)$, $(ḍ, ḍh-ṭh)$, $(d, dh-th)$, $(b, bh-ph)$, $(f-fh)$, $(z-s, ṣ, ś)$, and $(ḥ, h)$.

Looking back at Table 1, one can see that all characters in the first column of that table are middle characters, in the second column high characters, and in the third and the fourth columns low characters. The pairs above are mainly pairing among these columns, namely the third and the fourth ones with the second. There seems to be one of the columns which is left unmentioned so far, that is the fifth column.

Every alphabet of the fifth column belongs to the sonorants mentioned earlier on page 239. Sonorants are low characters without a partner. Similar to the third column characters which we pair with characters of the second column, all of which end with an *h*, we now pair the sonorants with itself and an *h*.

We are now in the position to give some examples which cover all possible cases of tone formation. For the middle characters, these are the following.

kạ, kặ, kà, kā́, ká

–, ka, kà, kā, –

kạn, kặ, kàn, kā́n, kán

kin, kĭn, kìn, kīn, kín

–, kạb̚, kàb̚, kā́b̚, –

–, kob̚, –, kōb̚, –

For the low and the high characters together the following.

gạ, khặ, gà(khà), gā́, khạ

–, kha, gà, ga, –

gạn, khặn, gàn(khàn), gā́n, khạn

gon, khŏn, gòn(khòn), gōn, khon

–, khạb̚, gạb̚, gā́b̚, –

–, khob̚, –, gob̚, –

And for the sonorants, pairing with themselves.

h'ed, (*mạ, mhặ, mà(mhà), mā́, mhạ*

–, mha, mà, ma, –

mạn, mhặn, màn, mā́n, mhạn

min, mhĭn, mìn(mhìn), mīn, mhin

–, mhạb̚, mạb̚, mā́b̚, –

–, mhob̚, –, mob̚, –

Notice that tone marks are only shown where a tone mark would have been written in Thai script. To give meaning of some of the words in these example, *kạ* is a crow, *ks* means to approximate, *kàn* means twig, *kàb̚* is the 'quack!' onomatopoeia of ducks while to *kin* is to eat, *gà* is 'yes' when a woman says it while *ga* is 'what?' when she asks, *gā́n* is to object, *gā́b̚* is a boy saying 'yes, sir!', *gon* is us humans but the opposition *khon* is the hair on your body, in particular *khob̚* means to bite but *gob̚* is to acquaint oneself with someone, *mạ* means to come, *mà* is mother, *mā́* is a horse but *mhạ* is a dog, and to draw *màn* is to draw a curtain.

As to be expected, the sonorants *y* and *v* seem to be rather unusual. Theoretically speaking *y*, *ẏ* and *v* when with vowel and having the second tone sound can, though some stretch may be required in certain cases, be have two forms, either with or without an *h*. In practice, however, only four for the forms without *h*'s are meaningful. These four are *yặ, yŭ, yặng*, and *yạk*, the sound of which is identical respectively with *yhặ, yhŭ, yhặng*, *yhạk*. They are famous because they are rare as well as for the fact that together in that order, *yặ yŭ yặng yạk* [or yặ yŭ yặng yạk], they are a saying of a sage 'never cravingly live!'. Can an idea of hints from past generation be excluded?

All long compound vowels which end with a vowel other than *e*, namely *ạu, ịa, ọa*, and *ụa*, when they have a final consonant, can be replaced by their short form for simplicity. For example *sauï* – 'to pick something from above with a long stick', *sauḅ* – 'exam', *siaḅ* – 'stab', *soaï* – 'beautiful', *loak* – 'to parboil', *d́uaï* – 'spur', *d́uan* – 'moon'.

To summarise, there are four groups of vowels. The first group contains all the pure vowels *a, ạ, i, ị, u, ụ, e, ẹ, o, ọ*, all of which combine equally well with final consonants.

The second group contains *ue, ụe, ae, ạe, oe, ọe* which are a little more complicated than vowels of the first group and are comparable with vowels with umlaut in German. All of them could join up with a final consonant, but most of the time they produce a long voweled sound. Three of them, *ụe, ạe, oe* or one from each pair, combine with a final consonant more often than the rest, but the result always gives a long-voweled sound even for *oe*, which is short. In other words, this group has more tendency towards long vowels than the first group.

The third group contains compound vowels of *au, ạu, ia, ịa, ua, ụa, oa, ọa*, all of which invariably give long vowels when they combine with final consonants. Therefore it suffice that we always use only their short forms *au, ia, ua, oa* when they have final consonants. This is easy to remember since they are paired vowels with final alphabet other than *e*.

The fourth and last group, containing *aṃ, ai, aị* and *ao*, poses no problem since none of them has a direct pair within the same group. I shall only give one example here, the following three words are in increasing order of vowel length, *kvaá* ('brandish') is a short vowel of the first group, *koá* ('intensive; chase') is of the third group, and *kvạá* ('sweep') is a long vowel of the first group.

Furthermore, each vowel in the first group is a monophthong, in the second an umlauted monophthong, in the third a diphthong, and in the fourth group a syllabic morpheme. The syllables in the fourth group each comprises of a vowel followed by an intrinsic consonant, namely *m* in the case of *aṃ*, *y* in the cases of *ai* and *aị*, and *v*, that is *w*, in the case of *ao*. Notice that *ai* and *aị* are not considered diphthongs as would have been the case with English. Rather they are both considered as *aï*, that is to say a vowel *a* plus a consonant *y* in its c_2-form *ï*.

The combination *aï* does exist in the first group, so this represents an example where there are several ways to write the same syllabic sound. Likewise, *ao* in the fourth group is in fact the *a* of the first group plus the consonant *v*, theoretically giving *aw*, a combination which unfortunately does not exist in the first group, therefore *ao* is unique and helps out where the first group falls short.

Also, when the vowel *ạe* in the second group above contains a tone mark as well as a final consonant, it may be replaced by its short form because whenever a final consonant exists *ae* always implies a *māităigṵ*, which is never coexists with a tone symbol. For example *khaeng* ('hard') is short and distinct from *khạeng*, though I still have to find out what it means if indeed it ever has a meaning, but *khàeng* ('leg') has no such long-voweled counterpart as *khậeng* because of the reason given above.

§ Syntax

Similar to all languages in the Tai family where it belongs, Daiï is a language with neither conjugations nor declensions. The same nouns are used for both nominative and accusative cases, and instead of the various cases, in Pali or Latin for example, preposition can be used when there is a need to clarify. The dative case, for example, can be translated into Thai by the help of *kặe*, the genitive case by *khaung*, the vocative case by *ḍụkaur* or *khậtặe*, and possibly the ablative case by *ḍọï*. Furthermore, the same nouns are used with no modification for both singular and plural meanings.

Without conjugation, different tenses are only possible by using adverbs of time or other modifiers. Therefore *khao pai*, 'he goes', becomes *khao pai lāeö* 'he has already gone', *khao ḍài pai* 'he had gone', *khao ḍài pai lāeö* 'he had already gone', *khao ca pai* 'he will go', *khao kaṃlang pai* 'he is going', and *khao kaṃlang ca pai* 'he is going to go'. In general, *ḍài* for 'did' does indicate past tenses, *lāeö* means already and therefore perfect tenses, *ca* meaning 'will' or 'shall' indicates future tenses, *kaṃlang* the

continuity of action and ultimately *kaṃlang ca* some current plan.

Daiï sentences have a construction [*subject verb object*] in general. Modifiers always come after the nouns they modify and never before them. For example *gon ǻị* – 'good person', *nhangsụe dị̀ nạ̀soncaị* – 'book that is interesting' or 'interesting book', *plạ naị dalẹ* – 'fish in the sea', and *ǻạögrauk̶a* – 'planet', where *ǻạö* or 'star' is modified by *grauk̶a* which means 'fate'.

There are no possessive pronouns in Daiï. Possession is expressed by *khaung* which means 'of', and it can be omitted, especially when this will cause no ambiguity. For example, it may be easier to replace *nhangsụe khaung chan*, 'my book', by *nhangsụe chan* than to replace *nhangsụe khaung khao* by *nhangsụe khao*, for the reason that *khao* in the latter case could sometimes represent the book itself instead of its purported owner.

The verb *to be* translates into three different words, namely *pen*, *yŭ* and *gụe*. The first one of these, *pen*, represents a state or status. Thus *khao pen bì* 'he is the elder', *chan pen grụ* (I am a teacher).

Yŭ specifies a location, *nhangsụe yŭ nhai?* 'where is the book?'. It is seen with the preposition *dì*, 'at', the last example being in fact shortened from *nhangsụe yŭ dì nhai?*.

And *gụe* is used when saying something which is always true about a certain thing, *śatrụ gụe yạjụkaṃlang* 'enemies are energising medicines'. It is also used when giving a definition, or when asking a definition of something, *kạrb̀àn gụe arai rao mài son*, 'who cares what homeworks are'.

Either side of both *pen* and *gụe* needs have either a noun or a pronoun, adjectival attributes without either one of these being out of the question. Therefore, depending on the context and sometimes despite of it, *grụ ǻị* could mean 'the teacher is good', 'a good teacher', or even 'teacher Dee' if it could be argued that the original text is actually written *krụ Ǻị* with a capital *Ǻ*.

Yŭ, on the other hand, may have either a noun, a pronoun, an adjective, or a clause comprising these as its object. Some examples are, *khao yŭ b̀àn* 'he is home', *khao yŭ dì b̀àn* 'he is at home', *nhangsụe yŭ tài tō* 'the book is under the table', and *pholāmāi yŭ sụng* 'the fruit is high up'. It also occurs in many expressions, for examples *yŭǻị kinǻị* 'well off', *yŭyen pensukh* 'lead a happy and peaceful life'.

It may not be at all incorrect to say that Daiï is a godless language. This is so too with all Eastern languages, for example Chinese. That is because in these languages there is no concept of 'existence' whatsoever. 'To be' in Daiï, for instance, is *pen*, *yŭ*, or *gụe*. But the other meaning of the verb that means 'to exist' may find no expressions in Daiï, simply because there are absolutely no words to express the idea.

The same is true with Chinese, where 'to be or not to be' in Hamlet has been as 'to live or to die.' Philosophers would immediately perceive that this is nonsense, because the latter is nothing whereas the former, being related to free choice and creation, everything. Translating everything into nothing could be called remarkable to say the least. Hamlet would have been a comedy had Hamlet said, 'to live or to die, that is the question.' Similarly all our *pen*, *yŭ* and *gụe* are in fact merely the nothing of 'to be'. These make up the Daiï definition of the word, but the existent meaning of the verb is completely lost. But it is a tragedy precisely because he said instead 'to be or not to be.' Since all questions of existence are directly related to God, one could term these languages where there no concept of existence exists godless.

Pentòn is an auxiliary that is often written after the last one of the items listed after *yok tọayặng jèn* which means 'for example'. It may be well to think of this combination *yok tọayặng jèn* ... *pentòn* as meaning 'take such examples as ... for instance'.

Two major machineries for creating nouns in Daiï are the prefixes *kạr* and *gvạm*. *Gvạm* gives nouns of abstract meaning or those which describe quality of things. It usually prefixes an adjective. But it can also prefix a verb for certain quality of the senses. For examples, *gvạmd́ị* 'virtue', *gvạmlẹ̈ö* 'vice', *gvạmrū* 'knowledge', *gvạmrak* 'love', *gvạmrūsuek* 'feeling' or 'sense', *gvạmsa̲d́oak* 'convenience', *gvạmnàrak* 'cuteness', and *gvạmcrọeñ*.

On the other hand, *kạr* always prefixes a verb of action, for example *kạrdaṃngạn* 'working', *kạrrian* 'study' or 'studying', *kạrkin* 'eating', *kạryŭ* 'being' or 'living', and *kạrkradaṃ* 'deed'. In general nouns that are made of a verb prefixed by *kạr* can be translated using the present participle of English.

Kạr, from *Pa.* and *Sk.* 'kå.ra', has four usages. As a noun, it means 'work' or 'business'. When it suffixes a noun, it means doer of some work, profession, or craftsmanship *eg*, *dhura̲kạr* 'administration', *kumbha̲kạr* 'pot-maker' or 'potter'. When it prefixes a noun, it means

duty or indicates what is being done *eg*, *kạrprapạ* 'department of water supply', *kạrfaifạ̄* 'electricity authority', and *kạrmuang* 'politics'. And finally, as we have seen, it can prefix a verb and make it a noun, as in *kạrnaun* 'sleeping'.

When *gvạm* converts an adjective into a noun, the end result usually contain one of those suffixes which convey a meaning of an abstract quality, while *kạr* normally changes a verb into a noun whose meaning in English contains a suffix expressing an action. For a few more example *gvạmjòa*, 'wickedness'; *gvạmklạ̀*, 'intrepidity' or 'braveness'; 'feeling', *gvạmrūsuek* when it means emotion which is an abstract quality, and *kạrrūsuek* when it means the action of sensing something.

Prefix and suffix in Daiï are in fact a method of creating new words characteristic to both Pali and Sanskrit. Here there are two ways to form a new word. They are called *sa̲mạs* and *sondhi* in Daiï. The former is a concatenation of two words together while in the latter the two words merge together with some change to each one of them at the place where they join. I will not go into detail about either one of them here.

But there is one other interesting thing which I think is a unique characteristic of Daiï. Ways how one can play with words often differ from one language to another, and it often pays to give a little reflection on something like these if one wish to get to know a language.

One of the joy in most languages is pun. Puns in Daiï have got a character of their own. Words are usually transformed in such a way that vowels and final consonants of the syllables concerned are exchanged in pairs across the middle of the word of sentence in question, the two member in each pair being equally far from that midpoint. Throughout this process all leading consonants retain their position. If the number of syllables is odd, then the middle syllable stays intact while those on either side of it change. For example, *Sa̲pūtnik* (Sputnik) puns to *Sa̲pīknut*. This example shows for one thing that one may choose to pun only a certain part instead of the whole phrase. One can also see here how the stressed and unstressed syllables have a role to play in making one such choice better than others. Certainly in this case *Sikpūtna* would have sounded less becoming. A few more examples are, *tok kraḋai blauï cọn*, a Daiï proverb which means 'dive down the rest of the way after having fallen off a ladder', could pun either to *tok kraḋọn blauï cai* or to *tọn kraḋai blauï cok* depending on whether one chooses only the final three syllables or the whole phrase; *ḋọen pai daṃngạn*, 'walk

to work', which can only pun to give *ɗạn pai daṃngoen*, 'Dan goes and make money', punning around more than one centre being generally out of question and dropping the first syllable which has a long vowel is not possible.

As mentioned, the stress or weight given to various syllables is not the same. The differentiation is whether it is stressed or not only. As such, there is only one degree of stressedness and no stressed syllable can be said to carry more weight than others. A syllable is called *gru* if it has weight. Otherwise it is called *la̲hu*.

Another feature worth mentioning is spoonerism. There seems to be no fixed rule for the creation of a spoonerism apart from to make it difficult for anyone to say it quickly and correctly. An individuality factor comes in to play here, and a spoonerism for one person may seem dead easy for another. One example, *grai khạï khặ̆kặ̆*, 'who sells hen's eggs?', is difficult because of the play on the tone of syllables which otherwise sound identical. Another example, *da̲u da̲hạr thụe pụen ḅạek pụn pai ḅọk tuek*, 's for soldier who holds a rifle while carrying lime mixture to plater a building', plays with two consonants with similar sound, *ḅ* and *p*.

Simile in Daiï is called *upa̲mạ upa̲maiï*, *upa̲mạ* meaning the act of comparing and *upa̲maiï* the things which can be compared. Daiï has no metaphors but is rich in onomatopoeia.

Various prefixes are used to describe professions. *Nak* is used to specify a profession or area of study *eg*, *nakrian* 'student', *nakvida̲yaśạstra̲* 'scientist', *nakgnitśạstra̲* 'mathematician', and so on.

Jạ̀ng is used both for craftsmanship and professions, *esp* of mechanic or engineer *eg*, *jạ̀ngdạuphạ̀* 'weaver', *jạ̀ngmāi* 'carpenter', *jạ̀ngdaṃphom* 'hairdresser'.

Phù is used to show duty or obligation when it precedes a verb *eg*, *phùtroackạr* 'inspector', *phùjāiraengngạn* 'labourer'. It can also precede an attributive adjective, where it means someone with that attribute, for example *phùrặ̄ï*, 'baddy'; *phùɗị*, 'goody' or 'people with a gentlemanly manner'; *phùsụng-ạyu*, 'elderly person'.

Gon is used for professions, *esp* those menial or routine in nature *eg*, *gondaṃgvạmsa̲wạɗ* 'cleaner', *gonkeḅkha̲ya* 'rubbish collector'. It is also used for citizen of a country, *gondaiï* 'Daiï', *gonangkṛiṣ* 'English', *gonciṇ*

'Chinese', *gonyị̀pŭn* 'Japanese'. In all cases it can be looked at as simply itself, which means 'man' or 'human', and then add modifiers.

Concatenating a rhyming phrase to a word is usual in Daiï. Instead of *klàḥañ*, 'braveness', one may say instead *klàḥañ jañjaï* which amounts to exactly the same thing apart from a somewhat more colourful nuance added. Such a part may also contribute some meaning, as is the case with the example above, but this need not be the case. Many of the noun phrases are simply a collection of nouns having a related meaning put together *eg*, *kàew vhaen ngoen daung* which means 'worldly possession' or 'material wealth', being put together from the four component words each of which means 'precious stones, rings, silver' and 'gold' in that order. Some tailings are only alliteration or assonance, others are purely imaginative, yet others contribute certain nuance which change the purpose or the meaning of the sentence.

One can make a sentence more or less polite by simply adding a certain word at the end of the sentence. Such words not only carry with them a degree of politeness but also the gender of the speaker. For example, both *gà* and *graḅ* are polite but the former is invariably feminine while the latter is always masculine. Generally speaking, one only use a polite ending when talking with someone older than oneself. Thus a male speaker never uses *gà* and similarly a female never uses *graḅ*, except possibly when addressing someone of the sex appropriate to the word, for example a woman may say to her small male relative sentences which end with *graḅ*. As examples of words other than these two which are used for ending a sentence: *cà*, *cā*, *yà*, *ḥa* and *ḥà*.

Most of these words which have no final consonant are used in their fourth tone unless they mean an affirmation, in which case they change to the third tone. Therefore *ga* is used in normal sentence, while both *gà* and *cà* mean a 'yes'. But this is no absolute rule and one never uses *ḥà* for an affirmation, for example, unless one intends to sound pretentious. Instead, *ḥa* is an ending with a neutral nuance which one should only use in that form for both cases.

Comparative and superlative in Daiï is as simple as simply adding *kvặ* and *dị̀suắ* respectively at the end of the adjective of adverb concerned. Therefore [*ắị, ắịkvặ, ắịdị̀suắ*; 'good, better, best'] and [*reö, reökvặ, reödị̀suắ*; 'fast, faster, fastest'].

Hài as a verb means 'to give', but when it follows another verb what follows it becomes the ultimate result or purpose of that action.

When functioning in this way, it is no longer a verb and can generally be replaced by the mathematical expression 'such that', for example *rian hài coḥ*, 'study in such a way that you graduate', in other words, 'learn such that you may leave'. It has an imperative meaning and may be understood as an exclamation mark to imply an order if what follows it is an adjective or adverb instead of a noun, *eg fang hài khàocaị*, 'listen well!'; *ɗụ hài ɗị*, 'look carefully!'.

To turn a command into a request, simply either append *zi* to the end of the sentence or precede it with *karuṇạ*, but never both. Examples are, *daṃ zi*, 'do it, will you?'; *karuṇạ yặ sŏngsiang ɗang*, 'please do not be loud'. Note that this *zi* has various variants, each of which gives different nuances which I am not prepared to go into details now, for example there are *si*, *zī* and *zị*.

Dị introduces a relative clause into a sentence, and can have various meaning *eg*, 'that, who, which, whom', *etc*. *Gon dị mạ sạï* means 'those who come late'.

To negate any part of the predicate, be it a verb, adjective or adverb, simply put *mài* in front of it. For example, *fang mài rūrùang*, 'comprehend not'; *mài fang*, 'listen not'; *mài gàocaị*, 'understand not'.

Every noun has a classifier intrinsic to itself. All nouns are divided into groups, all members of each one of which share the same characteristic among one another. These classifiers are used for counting a number of things. The syntax for this is 'noun' plus 'quantity' plus 'classifier', for example *sunakh sạm tọa*, 'three dogs'; *jặ̄ng nhŭeng juak*, 'an elephant'; *rothyonta saung gan*, 'two cars'.

When there is only one item of the thing in question one can instead use a noun followed by a classifier followed by *ɗiaö* as in *pạkkạ ɗậm ɗiaö*, 'only one pen'. Here *ɗiaö* means a quantitative 'only'. Some of the classifiers can also acts as a noun, then they can even be modified by the very now they describe, for example [phăen kraɗạṣ], 'paper-leaf'.

Some of the more common classifiers are given in Table 11.

Classifier	*Things classified*
an	generic term applicable to most material things
bạị	for plates, glasses
dàun	for timbers, parts a poetry or a song
ḍậm or *dàeng*	for long or cylindrical things, *eg* pen, pencil
ḍoang	for stars, planets, light bulbs
gon	for human
gan	for land vehicles
grùang	for pieces of a machine
gù	for pairs of things, *eg* shoes, socks, gloves and chopsticks
kàun	for lumps of things
laṃ	for clafts that travel in the air, or in or on the water, and also for bamboo sticks
meḍ	for buttons or seeds
phăen	for flat leaves
ruan	for clocks or watches
rụp	for Buddhist monks
sèn	for strings, roads
tọa	for animals, pieces of furniture
zì	for teeth, and also for long slender things lining up in rows, *etc*

Table 11 *Common classifiers*

Apart from these, a few other things are classified using the same word for the noun in question itself, *eg khoaḍ* for bottles; *pŭm* for switches or buttons; *thạeö* for rows, *etc*.

Regarding *numbers*, the number one changes from *nhŭeng* into *eḍ* when occurs in a compound, for example 'seventy-one' *ceḍsiḅ-eḍ*, but not when there is a zero before it, for example 'two hundred and one' *saungrāuïnhŭeng*. 'Twenty' is *yìsiḅ*, but apart from this the rest has no exceptions, *i.e.* 'eleven, twelve, thirteen' are respectively *siḅ-eḍ, siḅsaung* and *siḅsạm*. *Ordinal numbers* in Daiï are simply *dị* plus numbers, for example *sạm* 'three', *dịsạm* 'third'.

Modifiers always come after the things that they modify, and so adverbs come after verbs. Therefore *vìng reö* – 'run fast', *daṃ màipen* – 'do without the knowhow' or in other words 'know not how to do', *kin hàị chămṃcaị* – 'eat to one's heart's content', and *kậö pai klai* – 'go far'.

The word *ḍạö* or 'planet' originally means only those nine plan-

ets influential in astrology, namely *bra-ạdity̲a* (the sun), *bracandr̲a* (the moon), *bra-anggạr* (Mars), *brabudh* (Mercury), *brasaor̲a* (Saturn), *brab̲aṛuehas̲ab̲aúḍị* (Jupiter), *brarạhụ* (Neptune), *braśukr̲a* (Venus), and *brakẹtu* (Pluto). The word for 'the nine planets' in Daiï is *dạö nob̲agrauk̲a*.

The word for 'chess' in Daiï is *mhạkruk*. Daiï chess differs slightly in rules from the international chess game. The equivalence in it of a 'horse' is called *mạ̄* (horse), a 'rook' *rụa* (boat), a 'king' *khun* (king), a 'bishop' *gọn* (base), a 'queen' *meá* (seed), and a 'pawn' *bị̀a* (cowry shell). One of the literatures I come across in Europe, obviously mistakenly reading *gọn* as *khọn*, the classical masked Daiï dance, explain 'bishop' as meaning 'mask'. This is a pity since the author and the editor thereof were otherwise very respectable experts on the subject of chess, and they obviously know more about various variants of chess, *eg* Chaturanga, Shatranj and Shogi more than I ever know about anything including Daiï grammar. Obviously there is a discrepancy between the dictionary they use and their information about Daiï chess. So to me this example does at least help justify writing this book.

The number five is somewhat special in Daiï, one can safely say that it is a virtuous number. The Daiï word *bẹ̣ñc̲a*, coming from *pañca* in Pali, finds much use in the classification of things. *Bẹ̣ñc̲arongg̲a* is the five colours, namely *khạö* (white), *ḍaṃ* (black), *lhuang* (yellow), *khiaö* (green), and *dạeng* (red).

Bẹ̣ñc̲abaṇr or *bẹ̣ñc̲avaṇr* also mean 'five colours'. On the other hand they can also mean 'five kinds', and the former is used to name a kind of forest unique to Thailand which is renowned for the richness of its flora. There are certainly more than five kinds of trees in such forests, but the accuracy must make way for the preference towards the number five.

Bẹ̣ñc̲abhụt is the five elements of old, that is *Ḍin* (Earth), *Nāṃ* (Water), *Lom* (Wind), *Fai* (Fire), and *Ạkạś* (Air).

Bẹ̣ñcạngg̲a is the 'five parts' of a plant *rạk* (root), *pluak* (bark), *bạị* (leaf), *ḍauk* (flower), and *phol* (fruit). *Bẹ̣ñcạngg̲apraḍiṣṭ̲ha* is a standard worship posture of thai Buddhism in which five parts of the body simultaneously touch the ground. These five parts vary, some say that they are the head, the hands and the knees, others say they are the head, the hands and the elbows, but all agree that they represent *Brabuddh̲a* (the respected Buddha), *Bradhamrma* (the respected Dhamma, the philosophy that he discovered and teaches), *the respected Songg̲ha* (all his

disciples collectively, who keep *Dharrmma* alive), *ḅiḍạ maṛḍạ* (mother and father), and *gruṵḅạ ạcạr* (all one's teachers collectively). The necessary procedure starts from sitting upon one's knee and the balls of one's feet. Next bring down in sequence, first simultaneously the hands, then likewise the elbows, and then finally the head. Do all of these not too quickly five times and one has completed a *ḅẹ̃ñcạnggạpraḍiṣṭḥa*.

Ḅẹ̃ñcạkalạyạṇị refers to any woman who has the following five desirable traits, nice hair, nice flesh, *i.e.* ruddy gum and lips, nice teeth, nice complexion, and nice age, that is to say who is fitting at all ages.

And then the *ḅẹ̃ñcạkạmạguṇ* is the five things which humans desire, which are *rụp* (appearance), *siang* (sound), *klĭn* (olfactory sensings), *ros* (tastes), *samphas* (touch).

The vowels *ua* and *ụa* are in fact shortened forms of *uea* and *ụea* respectively, the latter of which in turn comes from *ụe* and *ạ*. *Ụe* is written in German as *ü*.

When the long vowels *ạu, ịa, ụa* and *ọa* have an ending consonant after them they can be respectively shortened into *au, ia, ua* and *oa* because there can be no ambiguities in that case. In other words only those long vowels which contain a single letter or end with and *e* need retain their long forms when occurring with an ending consonant.

In the Thai system of writing a vowel may stay the same or it may be changed or reduced from its normal form, for instance when a final consonant is added. The present system contains no such changes, and as for reduction the vowel that should have disappeared is written with a dot above it whenever there is a need to avoid ambiguity. In most cases this applies to an omitted *a* vowel, whereby it becomes *ạ*.

Example

Names and Places

There are currently 76 provinces in Thailand. In the middle part of Thailand there are Ảngdaung, Bejrḅuriị, Branȧgaurśriṵwayudhȧyạ or Ayudhȧyạ, Candȧḅuriị, Chajoengdrao, Jaynạd, Jolḅuriị, Kạycȧnȧḅuriị, Krungdẹbmȧhạnȧgaur or Krungdẹb (Bangkok), Lobḅuriị, Nagaurnạyok, Nagaurpaṭhom, Nondȧḅuriị, Padumdhạniị, Prạciṇḅuriị, Pracoaḅgịriḳhandȧha, Rayaung, Rạjȧḅuriị, Sȧmudrprạkạr, Sȧmudrsạgaur, Sȧmudrsonggrạm, Sȧraḅuriị, Singhaḅuriị, Srakȁew, Subarrṇḅuriị and Trạḍ.

The north-eastern part of the country includes Aṃnạccảroeỵ, Bụriṛamỷa, Jayảbhụmi, Kạlảsinḍhu, Khaunkặen, Lọey, Mảhạsạrảgạm, Mukḍạhạr, Nảgaurbảnom, Nảgaurrạjảsịmạ, Nhaungbọalaṃbhụ, Nhaunggạï, Rāuywed́, Sảkolnảgaur, Śrịsakẹṣ, Surindŕa, Uḅolrạjảdhạṇị, Uḍaurdhạṇị and Yảsọdhaur.

The North has provinces Bayao, Bejrảḅụrṇa, Bicitr, Biṣảṇuloḳ, Brặe, Jiangmhăi, Jiangrạï, Kaṃbạengbejr, Laṃbụn, Laṃpạng, Mặehàungsaun, Nảgaursảvarrġa, Nặn, Sukhọdaï, Tạk, Udaïdhạṇị and Utảrảḍitt̄ha.

In the south there are Badảlung, Bangngạ, Bhụket, Jumbaur, Krabỉ, Nảgaurśrịdharrmảrạj, Nảrạdhivạs, Pattạṇị, Ranaung, Sảtụl, Songkhlạ, Surạṣd́radhạṇị, Trang, and Yalạ.

Nhaunggạï has nine districts (ambhọes), namely Baurcảrọeỵ, Bọnbisaï, Ḅuengbrakạḷ, Dặḅặu, Muang Nhaunggạï, Sanggom, Śrịjiangmhặị, Zẹkạ and Zộbisaï. It has one sub-district (kĭng ambhọes), Pạkgạd́, which is under the Bọnbisaï district. Here the Khọng river serves as the border with Laos. Songgrạm River, coming from Bhụphạlhek, Bhụphạhak and Bhụbloen in Uḍaurdhạṇị runs through several districts of the province before merging with the Khọng River.

Plants are divided into Māi baịlīanggù or Dicotyledoneae, and Māi baịlīangd́ĭaw or Monocotyledoneae. Dicotyledoneae contains Annonaceae, Dipterocarpaceae, Euphorbiaceae, Leguminosae, Magnoliaceae, Moraceae, Nymphaeaceae, Rutaceae, Verbenaceae, *etc*. Annonaceae includes Kraḍangngạ, Laṃdoan, Nāuynhặ, Nāuynhộng, Nommạew and Sạïyhud́. Magnoliaceae includes Caṃpị, Caṃpạ, Moṇḍạ and Yị̀huḅ. Nymphaeaceae includes Pảdumjạti and Uḅoljạti, the latter of which has Ḅọaphan, Ḅọakhạḅ, Ḅọaphŭan, Niluḅol, Nymphae cyanea, Nymphaea lotus, Nymphaea stellata, Ratảwuḅol and Śảvẹtwuḅol (kumud).

Bibliography

Kit Tiyapan. *Thai Grammar, Poetry and Dictionary.* Bangkok, 2003

The Arts of Percolation

Kit Tyabandha, Ph.D.

February 2006

I never like to be in a crowd. It is terrifying how people coming together lose their identity to become mere items in a mob. Shakespeare knew this, for in *Julius Caesar* (Act III Scene II) Mark Anthony talks to the Roman people and raises such a mop that revenge the death of Caesar. The formation of mob is a percolation.

Percolation is a study of connection of components which appear in two states. Without losses of generality let us call these latter *yes* and *no*. Neighbour components having the same state form a cluster, which is sometimes called *animal*. As components change their state, the animals they form change their shape and size. These animals or clusters fall apart into smaller clusters, or merge with one another to form a larger one. They have a life and lifetime of their own.

Thinking individuals coming together form a group of people, a gathering. But a mob is a group of people in the same polarised state. However euphonious a word one may use, a mob is an animal. Individuality demands that no two persons are the same, and therefore differences are respected. But the criterion of mobilisation reduces individuality into binary states, one is either for or against that physical formation justly called a *mob*. Whether we like it or not, call it a witchcraft if you like, or describe it as black, but the fact remains the skill of mass mobilising is an art. Shakespeare obviously knows everything about it when he made his Marcus Antonius say, 'I come to bury Caesar, not to praise him. The evil that men do lives after them, The good is oft interred with their bones; So let it be with Caesar,' for indeed he was only there for the sole purpose of burying his dead friend Caesar. It was no fault of his that precisely by the end of his talk the Roman people mobilised to revenge Caesar's ghost. And those people led by Brutus, who together murdered Caesar, and who were all this time sitting by, did not notice anything wrong until it was already too late.

Cluster formation could be engineered. But the result would be in an excited, unstable state. Moreover, such clusters are rarely large enough to span the whole space, especially when the network has high

connectivity and is distributed. It is very difficult to engineer a mob, for instance, over a large area. There is a difference between a mob and the silent majority in democracy, in that the latter is a largest, space-spanning cluster called *percolating cluster*. Whereas it is possible to temporarily induce the former locally, the latter is invariably based on a pacific, that is peaceful process that goes on within a society which maintains a proper distance among the thinking individuals.

In percolation one needs to distinguish between the gradual process in the background and the abrupt phenomena that one notices on the outside. In this case the potential is everything, and the power nothing but a consequence of it. Thus the power of a good king is never in himself but in the people, and is rooted in the dedication and prudence they have seen in him in his position. Similarly the power of the media is also not in itself but in the people. Both blames for a thing which triggers a crisis, and credits for an immediate factor that heralds prosperity, tend to be an exaggeration. Take for instance a currency crisis. If the infrastructure, for instance basic education, decentralisation, political stability and privatisation are not strong, then one may not blame a crisis triggering factor, say a particular hedge fund. This is because at that point there must be several candidate factors at least, which could do exactly the same job of finishing off the economy. Percolation can pull you down, percolation can also push you up. If all the basic and fundamental things are in place and intact, then one may fear neither malicious factors nor external influences. Progresses, when they come, will sometimes be seemingly abrupt. But they will all rest on the same secure and less obvious ground where all the basics lie. Karma is nothing but percolation. And the percolation, resting on potentials, is ever silent.

One may represent a country as a network. Then the network's structure is more important than its transient indicators.

I risk being thought of as blaming the victim in place of the culprit when I say that the Thai economy came down in 1997 not because of the attack on the Thai baht by George Soros, a Hungarian-American and owner of a powerful hedge fund in the US, but it came down because Thailand was structurally weak and had too many unnoticed or hidden problems.

Thus the Thai economy came down *when* Soros's hedge fund attacked us, but it came down *because* of our own structural weaknesses.

The same thing would have to happen anyway, around the same

time as it did. According to the percolation theory, when a network is ripe, ready to undergo a change in phase, there are always several possible triggering events any one of which may do the job equally well.

In other words if it were not for the hedge fund, it would have been something else, *but*, and this is important, *the timing will not be far off*.

Bullies

Kit Tyabandha, Ph.D.

May 2006

Good friends often are different from each other. This rule of thumb is not necessarily restricted to people. Thus Winston Leonard Spencer Churchill (1874–1965) said in his speech on 30th December 1941, 'We shall never descend to the German and Japanese level', while Franklin Delano Roosevelt (1882–1945) on the other hand dropped the bombs on both Hiroshima and Nagasaki in 1945. The UK and the US seem to be two inseparable bosom friends.

We see a similar thing happened again when Tony Anthony Charles Lynton Blair (b. 1953) in 2002 preached educational programmes for the new, post-Taliban Afghanistan, while George W. Bush bombed the country's civilians.

Myself, I have no opinions because I do not personally know any of them, and it was not me who voted for them.

However, I think it is interesting to note that, at least in the case with the US, you sometimes have these namesakes who seem the worse side of their counterparts. George Herbert Walker Bush (b. 1924) ended the Cold War between the West and the Eastern Europe in 1989, and Theodore Roosevelt (1858–1919) received the Nobel Peace Prize in 1906.

God's Ayudhya's Defence

Kit Tyabandha, Ph.D.

What is God's Ayudhya's Defence?

Ayudhya was the capital city of Siam. It is possible that 'Śri Ayudhyå.' after *sandhi* becomes 'Śryayudhya'. Then the Daiï pronunciation of that is 'Syayudhya', which is then shortened into 'Syam' and then introduced as 'Siam' in the 16th century.

Ayudhya was a prosperous city of its time, but it was sacked twice by the Burmese on the second time of which it was completely destroyed. The term 'God's Ayudhya's Defence' was coined after the sack of Ayudhya. Thus it means an absolute faith in God, the same Jesus had when on the cross he said, 'I want Your will, not mine.'

The acronym of the name, that is to say, GAD also represents the name of G. A. Davies who was a supervisor for my Ph.D. Apart from that, Ayudhya was where one of my great-grandmothers came from. It was also the name of a school of weaponry which I attended, Ayudhya School, after my primary school and before my Sixth Form the which was done in New Zealand. It was a school which preserves the fighting style of Ayudhya's tradition.

Division of Space

Kit Tyabandha, Ph.D.

Random lines

Miles (1964) studies the line system, $p = x\cos\theta + y\sin\theta$, where $-\infty < p < \infty$ and $0 \leq \theta < \pi$. Chan (1990) studied numerical properties of such structure of random lines using the same generator and then used it to model the structure of non-woven media. This amounts to the study by simulation of filters the internal structure of which is fibre mat, for example polypropylene. The algorithm he developed deals with mechanical blocking and back-flushing of the fibres. Wilcock's study (1994), on the other hand, deals with woven materials. With them she tried to demistify the myth and mysteries surrounding the rule of thumb techniques in designing wire mesh demisters. Her algorithms first weave the mesh and then apply Monte Carlo to it for the simulation.

The steel and carbon fibres in cement pastes contributes respectively to hole- and electron conductions (Wen and Chung, 2000). This is a problem of percolation of interconnected random lines. On the other hand, we can also study the resistance instead of conductance, which is what Pennetta *et al* (2000) does for a random network of resistors. Interest in researches on random resistor or conductor networks is strong (for example, Pennetta *et al*, 2001). Cheng *et al*(2001) look at NiMH (nickel metal hydride) batteries' electrodes. In their presentation they wrap all the ends of those fibres that stick out from the prototile. This gives the periodicity which they use in their simulation. The NiMH has high porosity, no less than 97 per cent, and it contains two or more phases.

Some recent developments related to polypropylene are those done by Mironi-Harpaz and Narkis (2001), Narkis *et al* (2000), and Zhang *et al* (2001). Those who study the conductivity and resistivity of materials are, for example, Benoit *et al* (2001), Broderix *et al* (2001), Flandin *et al* (2001), Hindermann-Bischoff and Ehrburger-Dolle (2001), Huang *et al* (2001), Hunt (2001), Jevtic *et al* (2001), Nielson (2000), Petrovsky and Rak (2001), and Stenull *et al* (2001). An example of the application to dentistry is that which is reported by Sharp *et al* (2000). Rong *et al* (2001) look at tensile curves and study the resistance to thermal deformation in nanocomposites.

Bibliography

J. M. Benoit, B. Corraze, S. Lefrant, W. J. Blau, P. Bernier and O. Chauvet. Transport properties of PMMA-carbon nanotubes composites. *Synthetic Metals.* **121**, 1–3, 1215–1216. March 2001.

K. Broderix, H. Lowe, P. Muller and A. Zippelius. Critical dynamics of gelation. *Physical Review E.* **6301**, 1, 1510–1526. January 2001.

X. Cheng, A. M. Sastry and B. E. Layton. Transport in stochastic fibrous networks. *Journal of Engineering Materials and Technology, Transactions of the ASME.* **123**, 1, 12–19. January 2001.

Sen Chung Chan. *Studies of separation of dilute dispensions.* Ph.D. thesis. UMIST, Manchester, U.K. 1990.

L. Flandin, Y. Brechet and J. Y. Cavaille. Electrically conductive polymer nanocomposites as deformation sensors. *Composites Science and Technology.* **61**, 6, 895–901. 2001.

I. Mironi-Harpaz and M. Narki. Electrical behavior and structure of polypropylene/ultrahigh molecular weight polyethylene/carbon black immiscible blends. *Journal of Applied Polymer Science.* **81**, 1, 104–115. July 2001.

M. Narkis, G. Lidor, A. Vaxman and L. Zuri. Innovative ESD thermoplastic composites structured through melt flow processing. *IEEE Transactions on Electronics Packaging Manufacturing*. **23**, 4, 239–245. October 2000.

C. Pennetta, L. Reggiani, G. Trefan, F. Fantini, A. Scorzoni and I. de Munari. A percolative approach to electromigration in metallic lines. *Journal of Physics D, Applied Physics.* **34**, 9, 1421–1429. May, 2001.

C. Pennetta, G. Trefan and L. Reggiani. Scaling law of resistance fluctuations in stationary random. *Physical Review Letters.* **85**, 24, 5238–5241. December, 2000.

V. Y. Petrovsky and Z. S. Rak. Densification, microstructure and properties of electroconductive Si3N4-TaN composites. Part II. Electrical and mechanical properties. *Journal of the European Ceramic Society.* **21**, 2, 237–244. February 2001.

Min Zhi Rong, Ming Qiu Zhang, Yong Xiang Zheng, Han Min Zeng and K. Friedrich. Improvement of tensile properties of nano-SiO_2/PP composites in relation to percolation mechanism. *Polymer.* **42**, 4, 3301–3304. March 2001.

B. Sharp, D. Morton and A. E. Clark. Effectiveness of metal surface treatments in controlling microleakage of the acrylic resin-metal framework interface. *Journal of Prosthetic Dentistry.* **84**, 6, 617–622. 2000.

O. Stenull, H. K. Janssen, K. Oerding. Effects of surfaces on resistor percolation. *Physical Review E.* **6305**, 5, 6128–6141. May 2001.

S. H. Wen and D. D. L. Chung. Cement as a thermoelectric material. *Journal of Materials Research.* **15**, 12, 2844–2848. 2000.

Elaine Wilcock. *A study of mesh mist eliminators.* PhD thesis. UMIST. 1994.

H. J. Zhang, J. W. Wang, J. Li, S. K. Cao and A. Shan. Toughened polypropylene with balanced rigidity, III, compositions and mechanical properties. *Journal of Applied Polymer Science.* **79**, 8, 1345–1350. February 2001.

Ḋiaö

Kit Tyabandha, Ph.D.

'Ḋiaö' is a Daiï [dag] word I invented for the word 'God' in English. It was no invention really, since the same word did already exist in Daiï which was an adjective. The only things I did was to begin using it as a noun and capitalising it to describe 'Existence', that is God.

Thus in English 'One God' and in French 'Un Dieu' become in Daiï 'An Ḋiaö' That last word, 'An Ḋiaö' means 'The One', which in turn does not sound much different from 'Ḋiaö'. Both 'an' and 'ḋiaö' are Daiï words. I call 'Daiï' both what is normally known as the Thai language and the country Thailand.

Historically Christianity in Daiï owe much to Catholic influences. But these people tended to take words from the existing vocabulary instead of inventing new ones. With a godless language like Daiï‡

Thus the word for 'God' is usually 'Bracào', a prefix for kings, while the word for 'church' is generally 'bọṣtha', the renaming of the word 'uḅọsoth', which is a building in Buddhist temples. Both seem to me to be in a wrong register, and the universality of God is thereby lost through the translation.

[dag] By 'Daiï' I mean both the country whose usual name in English is 'Thai' and the language of that country, the word 'Daiï' being more grammatical correct than 'Thai'. For the people of the country, I use the word 'Daiïese' or 'Daiyese'

‡ I call a language 'godless' where there exist no concepts of existence. Synonym to the term 'godless' are 'existenceless'. In Daiï this can perhaps be expressed by such terms like 'rāi Ḋiaö', or 'rāi Bhavati'.

Percolation within Percolation

Kit Tyabandha, Ph.D.

The following programme was written in a macro language of Matlab. It was used in works leading to a Ph.D. thesis (Tiyapan, 2004). Percolation within percolation is the theme of that thesis.

Regular 3-dimension lattice

```
% trr.m, regular 3-d tesselation, (c) Kit Tiyapan, 16 Dec 2002
qn=size(q,1);
in2n=size(in2,1);
in3n=size(in3,1);
in5n=size(in5,1);
p=[];
p{1,1}=[o;o]';
p{1,2}=sz;
r=[];
s=[];
t=[];
for i=1:sz,
  r(1,i)=dx(m(i));
  s(1,i)=dy(n(i));
  t(1,i)=dz(z(i));
end
p{1,3}=r';
p{1,4}=s';
p{1,5}=t';
iin=size(ii,1);
tmp=ones(iin,1);
tma=sparse(tmp,ii(:,1),tmp,1,sz);
tmp=[];
tmb=[];
tmc=[];
tmd=[];
cnt=0;
for i=1:sz,
  if(~tma(i))
    cnt=cnt+1;
    tmp=[tmp;i,cnt];
    tmb=[tmb;r(i)];
    tmc=[tmc;s(i)];
    tmd=[tmd;t(i)];
  end
end
p{2,1}=tmp;
p{2,2}=cnt;
p{2,3}=tmb;
p{2,4}=tmc;
p{2,5}=tmd;
iiin=size(iii,1);
tmp=ones(iiin,1);
tma=sparse(tmp,iii(:,1),tmp,1,sz);
tmp=[];
```

```
tmb=[];
tmc=[];
tmd=[];
cnt=0;
for i=1:sz,
  if(~tma(i))
    cnt=cnt+1;
    tmp=[tmp;i,cnt];
    tmb=[tmb;r(i)];
    tmc=[tmc;s(i)];
    tmd=[tmd;t(i)];
  end
end
p{3,1}=tmp;
p{3,2}=cnt;
p{3,3}=tmb;
p{3,4}=tmc;
p{3,5}=tmd;
iv=[ii,2*ones(iin,1)];
for i=1:iiin,
  tmp=0;
  for j=1:iin,
    if(~(iii(i,1)-ii(j,1)))
      tmp=1;
    end
  end
  if(~tmp)
    iv=[iv;iii(i,:),3];
  end
end
ivn=size(iv,1);
tmp=ones(ivn,1);
tma=sparse(tmp,iv(:,1),tmp,1,sz);
tmp=[];
tmb=[];
tmc=[];
tmd=[];
cnt=0;
for i=1:sz,
  if(~tma(i))
    cnt=cnt+1;
    tmp=[tmp;i,cnt];
    tmb=[tmb;r(i)];
    tmc=[tmc;s(i)];
    tmd=[tmd;t(i)];
  end
end
p{4,1}=tmp;
p{4,2}=cnt;
p{4,3}=tmb;
p{4,4}=tmc;
p{4,5}=tmd;
vn=size(v,1);
tmp=ones(vn,1);
tma=sparse(tmp,v(:,1),tmp,1,sz);
tmp=[];
tmb=[];
tmc=[];
tmd=[];
cnt=0;
for i=1:sz,
  if(~tma(i))
    cnt=cnt+1;
```

```
    tmp=[tmp;i,cnt];
    tmb=[tmb;r(i)];
    tmc=[tmc;s(i)];
    tmd=[tmd;t(i)];
  end
end
p{5,1}=tmp;
p{5,2}=cnt;
p{5,3}=tmb;
p{5,4}=tmc;
p{5,5}=tmd;
vi=[ii,2*ones(iin,1)];
for i=1:vn,
  tmp=0;
  for j=1:iin,
    if(~(v(i,1)-ii(j,1)))
      tmp=1;
    end
  end
  if(~tmp)
    vi=[vi;v(i,:),5];
  end
end
vin=size(vi,1);
tmp=ones(vin,1);
tma=sparse(tmp,vi(:,1),tmp,1,sz);
tmp=[];
tmb=[];
tmc=[];
tmd=[];
cnt=0;
for i=1:sz,
  if(~tma(i))
    cnt=cnt+1;
    tmp=[tmp;i,cnt];
    tmb=[tmb;r(i)];
    tmc=[tmc;s(i)];
    tmd=[tmd;t(i)];
  end
end
p{6,1}=tmp;
p{6,2}=cnt;
p{6,3}=tmb;
p{6,4}=tmc;
p{6,5}=tmd;
vii=[iii,3*ones(iiin,1)];
for i=1:vn,
    tmp=0;
  for j=1:iiin,
    if(~(v(i,1)-iii(j,1)))
      tmp=1;
    end
  end
  if(~tmp)
    vii=[vii;v(i,:),5];
  end
end
viin=size(vii,1);
tmp=ones(viin,1);
tma=sparse(tmp,vii(:,1),tmp,1,sz);
tmp=[];
tmb=[];
tmc=[];
```

```
tmd=[];
cnt=0;
for i=1:sz,
  if(~tma(i))
    cnt=cnt+1;
    tmp=[tmp;i,cnt];
    tmb=[tmb;r(i)];
    tmc=[tmc;s(i)];
    tmd=[tmd;t(i)];
  end
end
p{7,1}=tmp;
p{7,2}=cnt;
p{7,3}=tmb;
p{7,4}=tmc;
p{7,5}=tmd;
viii=iv;
for i=1:vn,
  tmp=0;
  for j=1:ivn,
    if(~(v(i,1)-iv(j,1)))
      tmp=1;
    end
  end
  if(~tmp)
    viii=[viii;v(i,:),5];
  end
end
viiin=size(viii,1);
tmp=ones(viiin,1);
tma=sparse(tmp,viii(:,1),tmp,1,sz);
tmp=[];
tmb=[];
tmc=[];
tmd=[];
cnt=0;
for i=1:sz,
  if(~tma(i))
    cnt=cnt+1;
    tmp=[tmp;i,cnt];
    tmb=[tmb;r(i)];
    tmc=[tmc;s(i)];
    tmd=[tmd;t(i)];
  end
end
p{8,1}=tmp;
p{8,2}=cnt;
p{8,3}=tmb;
p{8,4}=tmc;
p{8,5}=tmd;
map=[];
tmp=ones(sz,1);
map{1,1,1}=sparse(p{1,1}(:,1),tmp,p{1,1}(:,2),sz,1);
cnt=p{1,2};
e=q;
V=[p{1,3},p{1,4},p{1,5}];
tmp=ones(p{2,2},1);
for i=2:nx,
  map{i,1,1}=sparse(p{2,1}(:,1),tmp,cnt*tmp+p{2,1}(:,2),sz,1);
  for k=1:iin,
    map{i,1,1}(ii(k,1),1)=map{(i-1),1,1}(ii(k,2),1);
  end
  cnt=cnt+p{2,2};
```

```
% +iin;
  for k=1:qn,
    e=[e;map{i,1,1}(q(k,1)),map{i,1,1}(q(k,2))];
  end
  for k=1:in2n,
    e=[e;map{i,1,1}(in2(k,1)),map{(i-1),1,1}(in2(k,2))];
  end
  V=[V;(i-1)*dim1*tmp+p{2,3},p{2,4},p{2,5}];
end
tmp=ones(p{3,2},1);
for j=2:ny,
  map{1,j,1}=sparse(p{3,1}(:,1),tmp,cnt*tmp+p{3,1}(:,2),sz,1);
  for k=1:iiin,
    map{1,j,1}(iii(k,1),1)=map{1,(j-1),1}(iii(k,2),1);
  end
  cnt=cnt+p{3,2};
% +iiin;
  for k=1:qn,
    e=[e;map{1,j,1}(q(k,1)),map{1,j,1}(q(k,2))];
  end
  for k=1:in3n,
    e=[e;map{1,j,1}(in3(k,1)),map{1,(j-1),1}(in3(k,2))];
  end
  V=[V;p{3,3},(j-1)*dim2*tmp+p{3,4},p{3,5}];
end
tmp=ones(p{4,2},1);
for i=2:nx,
  for j=2:ny,
    map{i,j,1}=sparse(p{4,1}(:,1),tmp,cnt*tmp+p{4,1}(:,2),sz,1);
    for k=1:ivn,
      if(iv(k,3)==2)
        map{i,j,1}(iv(k,1),1)=map{(i-1),j,1}(iv(k,2),1);
      else
        map{i,j,1}(iv(k,1),1)=map{i,(j-1),1}(iv(k,2),1);
      end
    end
    cnt=cnt+p{4,2};
% +ivn;
    for k=1:qn,
      e=[e;map{i,j,1}(q(k,1)),map{i,j,1}(q(k,2))];
    end
    for k=1:in2n,
      e=[e;map{i,j,1}(in2(k,1)),map{(i-1),j,1}(in2(k,2))];
    end
    for k=1:in3n,
      e=[e;map{i,j,1}(in3(k,1)),map{i,(j-1),1}(in3(k,2))];
    end
    V=[V;(i-1)*dim1*tmp+p{4,3},(j-1)*dim2*tmp+p{4,4},p{4,5}];
  end
end
tmp=ones(p{5,2},1);
for i=2:nz,
  map{1,1,i}=sparse(p{5,1}(:,1),tmp,cnt*tmp+p{5,1}(:,2),sz,1);
  for k=1:vn,
    map{1,1,i}(v(k,1),1)=map{1,1,(i-1)}(v(k,2),1);
  end
  cnt=cnt+p{5,2};
  for k=1:qn,
    e=[e;map{1,1,i}(q(k,1)),map{1,1,i}(q(k,2))];
  end
  for k=1:in5n,
    e=[e;map{1,1,i}(in5(k,1)),map{1,1,(i-1)}(in5(k,2))];
  end
```

```
  V=[V;p{5,3},p{5,4},(i-1)*dim3*tmp+p{5,5}];
end
tmp=ones(p{6,2},1);
for i=2:nx,
  for j=2:nz,
    map{i,1,j}=sparse(p{6,1}(:,1),tmp,cnt*tmp+p{6,1}(:,2),sz,1);
    for k=1:vin,
      if(~(vi(k,3)-2))
        map{i,1,j}(vi(k,1),1)=map{(i-1),1,j}(vi(k,2),1);
      else
        map{i,1,j}(vi(k,1),1)=map{i,1,(j-1)}(vi(k,2),1);
      end
    end
    cnt=cnt+p{6,2};
    for k=1:qn,
      e=[e;map{i,1,j}(q(k,1)),map{i,1,j}(q(k,2))];
    end
    for k=1:in2n,
      e=[e;map{i,1,j}(in2(k,1)),map{(i-1),1,j}(in2(k,2))];
    end
    for k=1:in5n,
      e=[e;map{i,1,j}(in5(k,1)),map{i,1,(j-1)}(in5(k,2))];
    end
    V=[V;(i-1)*dim1*tmp+p{6,3},p{6,4},(j-1)*dim3*tmp+p{6,5}];
  end
end
tmp=ones(p{7,2},1);
for i=2:ny,
  for j=2:nz,
    map{1,i,j}=sparse(p{7,1}(:,1),tmp,cnt*tmp+p{7,1}(:,2),sz,1);
    for k=1:viin,
      if(~(vii(k,3)-3))
        map{1,i,j}(vii(k,1),1)=map{1,(i-1),j}(vii(k,2),1);
      else
        map{1,i,j}(vii(k,1),1)=map{1,i,(j-1)}(vii(k,2),1);
      end
    end
    cnt=cnt+p{7,2};
    for k=1:qn,
      e=[e;map{1,i,j}(q(k,1)),map{1,i,j}(q(k,2))];
    end
    for k=1:in3n,
      e=[e;map{1,i,j}(in3(k,1)),map{1,(i-1),j}(in3(k,2))];
    end
    for k=1:in5n,
      e=[e;map{1,i,j}(in5(k,1)),map{1,i,(j-1)}(in5(k,2))];
    end
    V=[V;p{7,3},(i-1)*dim2*tmp+p{7,4},(j-1)*dim3*tmp+p{7,5}];
  end
end
tmp=ones(p{8,2},1);
for i=2:nx,
  for j=2:ny,
    for k=2:nz,
      map{i,j,k}=sparse(p{8,1}(:,1),tmp,cnt*tmp+p{8,1}(:,2),sz,1);
      for m=1:viiin,
        if(~(viii(m,3)-2))
          map{i,j,k}(viii(m,1),1)=map{(i-1),j,k}(viii(m,2),1);
        elseif(~(viii(m,3)-3))
          map{i,j,k}(viii(m,1),1)=map{i,(j-1),k}(viii(m,2),1);
        else
          map{i,j,k}(viii(m,1),1)=map{i,j,(k-1)}(viii(m,2),1);
        end
```

```
      end
      cnt=cnt+p{8,2};
      for m=1:qn,
        e=[e;map{i,j,k}(q(m,1)),map{i,j,k}(q(m,2))];
      end
      for m=1:in2n,
        e=[e;map{i,j,k}(in2(m,1)),map{(i-1),j,k}(in2(m,2))];
      end
      for m=1:in3n,
        e=[e;map{i,j,k}(in3(m,1)),map{i,(j-1),k}(in3(m,2))];
      end
      for m=1:in5n,
        e=[e;map{i,j,k}(in5(m,1)),map{i,j,(k-1)}(in5(m,2))];
      end
      V=[V;(i-1)*dim1*tmp+p{8,3},(j-1)*dim2*tmp+p{8,4},...
        (k-1)*dim3*tmp+p{8,5}];
    end
  end
end
en=size(e,1);
Vn=size(V,1);
figure(1);
clf;
hold on;
for i=1:en,
  plot3([V(e(i,1),1),V(e(i,2),1)],[V(e(i,1),2),V(e(i,2),2)],...
    [V(e(i,1),3),V(e(i,2),3)]);
end
axis off;
axis equal;
clf;
hold on;
tms=sum(nemat,2);
tmp=[];
tma=17.2;
% 5x5x5 units
for i=1:en,
  if(tms(i)<tma)
    tmp=[tmp;e(i,:)];
  end
end
tmn=size(tmp,1);
for i=1:tmn,
  plot3([V(tmp(i,1),1),V(tmp(i,2),1)],...
    [V(tmp(i,1),2),V(tmp(i,2),2)],[V(tmp(i,1),3),V(tmp(i,2),3)]);
end
axis off;
axis equal;
% for vertices
nvmat=sparse(Vn,Vn);
for i=1:en,
  nvmat(e(i,1),e(i,2))=1;
nvmat(e(i,2),e(i,1))=1;
end
A=V;
N=Vn;
lmat=sparse(1,N);
umat=sparse(1,N);
LB=min(V(:,1));
UB=max(V(:,1));
rng=UB-LB;
LBv=.05*rng+LB;
UBv=UB-LBv;
```

```
for i=1:Vn,
  if(V(i,1)<LBv)
    lmat(1,i)=1;
  end
  if(V(i,1)>UBv)
    umat(1,i)=1;
  end
end
nmat=nvmat;
Blocked=randperm(Vn);
[pc,cord,tsries]=perc(N,lmat,umat,nmat);
% for edges
evm=sparse(en,Vn);
for i=1:en,
  evm(i,e(i,1))=1;
  evm(i,e(i,2))=1;
end
nemat=sparse(en,en);
for i=1:Vn,
  tmp=find(evm(:,i));
  tmn=size(tmp,1);
  for j=1:(tmn-1),
    for k=(j+1):tmn,
      nemat(tmp(j),tmp(k))=1;
      nemat(tmp(k),tmp(j))=1;
    end
  end
end
A=e;
N=en;
lmat=sparse(1,N);
umat=sparse(1,N);
for i=1:N,
  if((V(A(i,1),1)<=LBv) | (V(A(i,2),1)<=LBv))
    lmat(1,i)=1;
  elseif((V(A(i,1),1)>=UBv) | (V(A(i,2),1)>=UBv))
    umat(1,i)=1;
  end
end
nmat=nemat;
Blocked=randperm(N);
[pc,cord,tsries]=perc(N,lmat,umat,nmat);
% ccp
clear all;
sz=9;
nx=5;
ny=5;
nz=5;
r=1;
tmp=sqrt(2)*r;
dx=[0,2*r,4*r];
dy=[0,2*r,4*r];
dz=[0,tmp,2*tmp];
dim1=max(dx);
dim2=max(dy);
dim3=max(dz);
q=[1,2;1,3;1,5;1,6;2,5;3,5;4,5;5,6;5,7;5,8;5,9];
m=[1,3,1,3,2,1,3,1,3];
n=[1,1,3,3,2,1,1,3,3];
z=[1,1,1,1,2,3,3,3,3];o=[1,2,3,4,5,6,7,8,9];
ii=[1,2;3,4;6,7;8,9];
iii=[1,3;2,4;6,8;7,9];
v=[1,6;2,7;3,8;4,9];
```

```
487 in2=[];
488 in3=[];
489 in5=[];
```

Bibliography

K N Tiyapan. Division of space by Voronoi graphs, percolation within percolation and application to the models of porous membranes. *PhD Thesis.* University of Manchester, 2004

Kit Tyabandha. Percolation within Percolation, Theory. *Tyabandha Journal of Arts and Science.* **3**, 2, 2006

Percolation within Percolation Simulation

Kit Tyabandha, Ph.D.

Particles suspended in a fluid generally have their diameter d_p much smaller than the pore diameter d_v of a filtering membrane. Yet these small particles can cause blockages of the membranes due to attrition among themselves. Since in this case $d_p \ll d_v$, blockages due to blocking or blinding of the individual particles (*cf* Jackson, 1994; Jafferali, 1995) become out of question.

Having investigated both the percolations of networks and continuum, I suggest that the blockage of these smaller particles in membranes is due to a double percolation phenomena, one the percolation of the suspension continuum, the other the percolation of the centroidal Voronoi network. As a reminder of a centroidal Voronoi network, it is a Voronoi tessellation on generator points which are the centroids of a Voronoi network which either is generated from Poisson point generators or is another centroidal Voronoi network.

Because percolation is a study of the behaviour of two phases, and because in general $p_c \neq 1/2$, there are not only two but no less than three states or regions of behaviour to consider in each percolational investigation (*cf* Tiyapan, 1997; also in Tiyapan, 2003). When $p_c < 0.5$ these three regions are $p < p_c$, $p_c \leq p \leq (1 - p_c)$ and $p > (1 - p_c)$, and when $p_c > 0.5$ they are $p < (1 - p_c)$, $(1 - p_c) \leq p \leq p_c$ and $p > p_c$. The case where $p_c = 0.5$ is assumed to be very rare in nature, and so can be neglected in the present study.

When a suspension becomes so concentrated that the average interparticle distance has become such that the attrition due to van der Waals force is prominent, it will solidify into a moisted bed of particles. According to the percolation theory, we may define the point where this spontaneous solidification occurs to be that point where there is a single cluster, under a mutual van der Waals force, which traverses the whole continuum in a certain well-conditioned direction, that is a direction which may represent the diameter of the network. Furthermore, let us call a critical concentration ρ_c the minimum concentration at which this infinite cluster appears.

Then we have for our suspension a continuum percolation with three regions of behaviour similar to those we have found in the case of network percolation. Furthermore we map the space of ρ_c on to that of $0 \leq p_c \leq 1$, where $p_c = 0$ means there are no particles suspended in the fluid, in other word $\rho = 0$, and $p_c = 1$ is where the suspended particles form a bed in the closest packed structure, that is $\rho = \rho_{\max}$. We also assume, without the loss of generality, that $p_c > 0.5$. Then we have the following as the three regions, $p < (1 - p_c)$, $(1 - p_c) \leq p \leq p_c$ and $p > p_c$.

We are interested in neither the cases $p < (1 - p_c)$ nor $p > p_c$, since the former implies too dilute a concentration for the attrition due to the van der Waals force to cause an infinite cluster, while the latter means that the suspension is so concentrated that they solidify instantaneously, simultaneously in all pores.

When $(1 - p_c) \leq p \leq p_c$, all pores has an equal probability of being solidified, and so the per cent total solidified cells now depends on the topology of the network, in this case Voronoi, and the probability where the critical phase change occurs becomes the critical probability of the network.

In the case of dead-end filtration the flow is in one direction, therefore the critical flux reduction which is the result of percolation of the network occurs at the point where the cross section of the network, not the network itself, percolates. This is because such percolation in the cross section in the plane perpendicular to the flow direction will cause a bottle neck in the flow and therefore determines the flux. This phenomenon is summarised in Figure 1.

Next we must define the critical probability of the overall system. Since the system involves two kinds of probability, that is continuum and network, and assuming p_{c_0} and p_{c_2} are two independent probabilities, then we have the overall probability is

$$p_c = p_0 p_{c_2}, \tag{1}$$

where $(1 - p_{c_0}) \leq p_0 \leq p_{c_0}$.

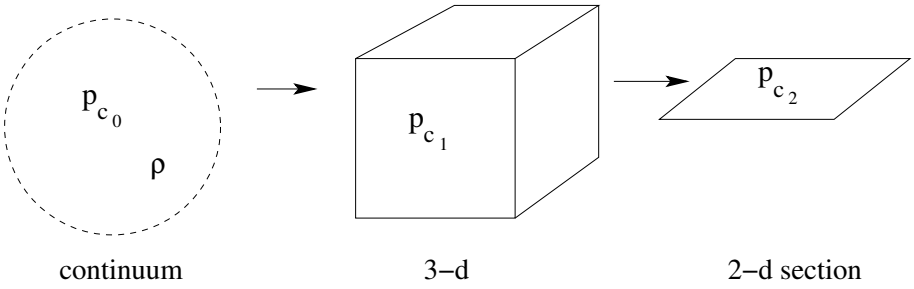


Figure 1 *Percolation within percolation;* $0 \leq \rho_0 \leq \rho_{\max}$, $0 \leq p_0 \leq 1$, $p_c = p_{c_2} \cdot p_0$.

If our membrane is homogeneous, the reduction in the area perpendicular to the flow becomes $\Delta A = A_v p_{c_2}$, where $V_v/V_t = A_v/A_t$, V_v and V_t are respectively the void volume and the total volume of the membrane, and similarly for the areas A_v and A_t.

The first part, suspended particles

Because of the complex nature of the problem, there is no single algorithm but rather there is an algorithm for each job. The first task is to study the percolation of the spherical particles under the van der Waals force.

Continuing from the development in Tiyapan (2004), particles are spherical in shape with $r_p = 5$ μm and the capturing radius is $r_c = 167 \times 1.2 \approx 200$ μm. First we shall study particles within a cubic box

of side length 2 mm. Particles start as a suspension with no obvious velocity. They stick together and to the walls.

When particles come together, they form a porous globule, having the densest packing density of the hexagonal or cubic close packing. When this happens, we discard the individual particles and consider instead the globular cluster which they formed. The cluster is porous, so its new radius is $r = (\pi/3\sqrt{2})(3\sum v_i/4\pi)^{1/3} = (\pi/3\sqrt{2})(3nv/4\pi)^{1/3} = \pi^{2/3}(nv)^{1/3}/(3^{2/3}2^{7/6})$.

But we do not know the rules by which these particles stick themselves together, whether they form a closest-packed globule or some other shapes. It is quite certain that whatever shape they are after, they may not retain it for long because there is a limited space within each pore that will put constraints on the way they grow. We shall call the growth of clusters into globules mentioned above *globular formation*.

Other clustering mechanisms possibly include what we shall call the *tetrahedra formation*. By this I mean that each one of our spherical particles attaches itself to three other particles, forming a tetrahedron whose side lengths are two times their radius. The next free particle may fit into any of the available attachment sites, *i.e.* the free triangular faces of an existing cluster. We may suppose that it always choose the closest one among such sites if this is available; if not, then the next closest one and so on.

These are only two among all the possibilities, namely the globular and tetrahedra formations. There could well be others, as well as a mixture of them. On the other hand, each material of which the particles are made may decide the particular cluster shape it prefers. Detailed analyses in thermodynamics and quantum mechanics are needed if we were to understand this cluster formation in continua under spatial constraints. Neither of these is within the scope and time constraint of the present work, though both of them merit a detailed investigation which I plan to carry out in the future.

Another problem arises when we come to consider percolation of our membrane. We may, for instance, say that it percolates when its structure in three dimensions percolates, or we may say that it percolates if there exists a cross section perpendicular to the flow which percolates in two dimensions. Since percolation of a cross section implies percolation of the structure but not vice versa, these two definitions of percolation due to suspension in membranes are not the same.

Choosing the percolation of sections as a criterion implies that we consider the superficial velocity of the flow whereas choosing the percolation in three dimensions as the criterion means that we focus on its interstitial velocity instead.

The algorithms for the study of percolation by tiny particles due to attrition in membranes which proposed here are Algorithm's 1 and 2. Algorithm 1 prepares the structure while 2 does the percolation simulation. Here both VT and $\mathcal{V}$ means the Voronoi tessellation. The appeal factor is the probability that a particle will choose to leave a cell via a certain bond. It is weight by the gradient of each bond, and is calculated over all bonds going in the downward direction from the cell. Transfer grids are square grids which help map the continuous plane at the top layer to bonds connected to it, that is to say, it maps a continuous Euclidean plane into discrete grids and from there on to bonds. In other words, $E^2 \to D^2 \to \{b\}$.

Algorithm 1 *Percolation by tiny particles due to attrition in membranes.*

generate a Voronoi tessellation in three dimensions**;**

transform the VT into a centroid VT**;**

find the cross section of its top layer**;**

$C \leftarrow C^2(\mathcal{V})$**;**

find transfer grids of C**;**

for every cell in VT **do**

find the maximum chamber capacity of its cell**;**

find appeal factors for all its bonds**;**

endfor □

Let the gradient of each bond be represented by an angle α that it makes with the horizontal plane. Then the gradient can be calculated from the coordinates of the two end points of each bond, providing that $z_2 > z_1$, from $\alpha = \tan^{-1}(z_{12}/((\Delta x)^2 + (\Delta y)^2)^{1/2})$, where the slope

is downwards from p_2 to p_1, and as usual $z_{12} = z_2 - z_1$. Algorithm 2 describes the membrane percolation simulation proposed.

Algorithm 2 *Percolation by tiny particles due to attrition in membranes, percolation simulation.*

for each time step **do**

for all arriving particles **do**

find their random arrival position**;**

round these positions to the precision of the grids**;**

map positions on to bond numbers, using the grids**;**

endfor

for all particles **do**

update distance travelled**;**

update chamber crowding**;**

find percolation of blocked chambers**;**

if chambers percolate **then**

terminate the simulation**;**

endif

endfor

endfor □

Here we concentrate on the interstitial flow velocity, therefore the percolation is supposed to occur when the chambers percolate in three dimensions. Coincidentally, this also makes the calculation easier. If

we were to choose the percolation of sections as the deciding factor for percolation of the membrane, for instance, we would have needed to consider approximately $2n$ sections in total, where n is the number of chambers. With an equal probability for success for all the homogeneous sections, this would still leave us on average n sections to consider before we know that a sample percolates, if it does, though we would still need to test all the $2n$ sections in cases where it does not. This number $2n$ arises from the fact that to completely cover all combinations of grouping cells into sections we need to consider for each cell two sections for each existing cell, one touching its top while the other touches its bottom.

Sphere packing is a rich field of its own, within which the packing density is generally referred to as η, an efficiency, instead of the usual density symbol ρ. The rigid packings of spheres vary in density from the lowest in loose packing where $\eta \approx 0.06$ to the highest, which is shared by the cubic and the hexagonal closest packings, $\eta \approx 0.74$. A rigid packing is a packing in which all spheres touch at least four others, and the points by which each sphere touches its neighbours can neither be all in the same hemisphere nor all on an equator, *i.e.* a greatest circular section. So we can now limit the value of ρ that we shall use to be in accord with $0.06 < \eta < 0.74$. In this early stage we shall not use a Monte Carlo study to find the probable ρ, *i.e.* η, but will approximate it to be some value within the range mentioned. Since the most familiar sphere packing in human history must be that by which oranges are stacked at markets, especially open markets like the one at Bolton, which gives the efficiency of packing $\eta \approx 0.74$, we shall assume that this is the way the clusters arrange themselves.

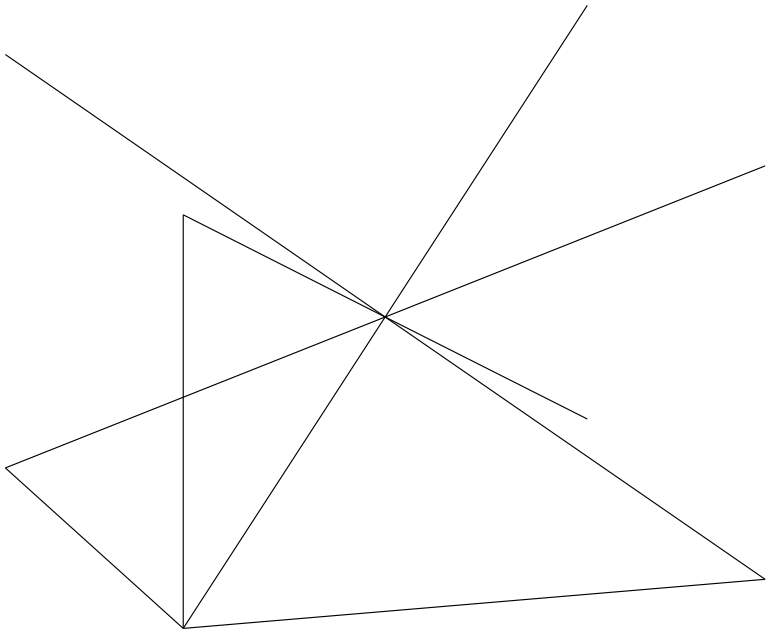
Notice also that piling oranges in a neat tetrahedral shape on a table and a packing them into a rectangular box both produce the same crystal structure, that is the face-centred lattice, the difference being only in their habits.

For all intents and purposes the percolation probability of spheres under the influence of the van der Waals force must be the same as p_c of a face-centred lattice. This is because the biggest cluster of both cases will have the same structure and their orientation will determine the orientation of the structure. We can do away with the orientation of other minor clusters precisely because they are much smaller, which justifies our grossing over their individual shapes and only concern ourselves about their statistics, that is to say, their number. I think that stacking oranges into a box is cubic close packing while a pile of oranges is hexagonal close packing, but this needs to be checked.

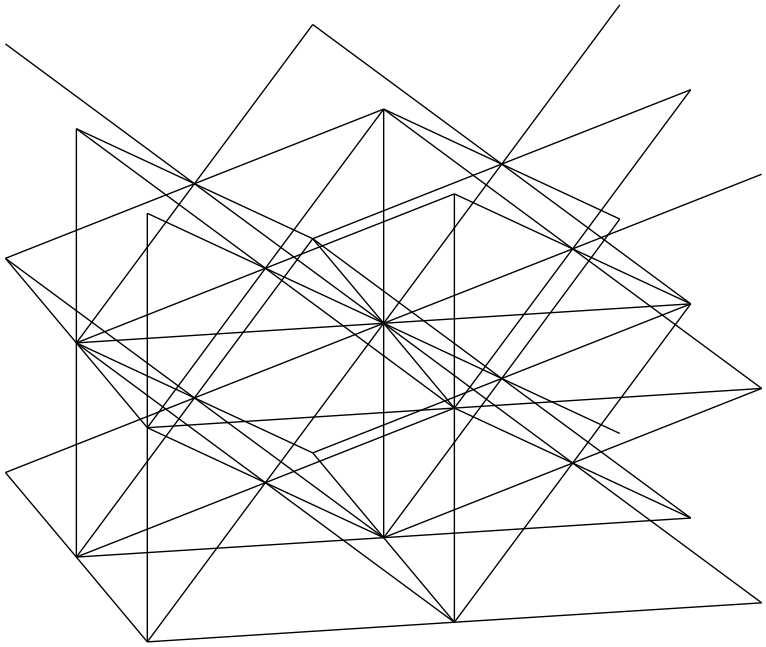
To find p_c of the close-packed cluster of spheres, one needs a programme similar to one of the those mentioned at the end, but which would do the job for three dimensions instead of two. For this purpose, the programme for 2-d tilings has been developed further to deal with regular lattices in three dimensions. At first I thought that there should be some other way to do this instead of having to develop another programme for a general lattice in three dimensions, since this is already the last week of the project and time is running out. But in the end I found it better to spend some time to systematically develop a programme for general cases than to opt for some adhoc approaches. As a result, a programme that creates regular lattices in three dimensions for the purpose of percolation study has been written and is listed at the end.

As the 2-d programme does for all 2-d regular lattices, this new programme can deal with all possible lattices in three dimensions. The difficulty is, however, in the meticulous nature of identifying all the vertices and links in each unit cell. In this respect, the cubic close packing is much simpler to do than the hexagonal close packing. Therefore we shall only do the first one while leaving out the second, which ideally could be used for the purpose of comparison.

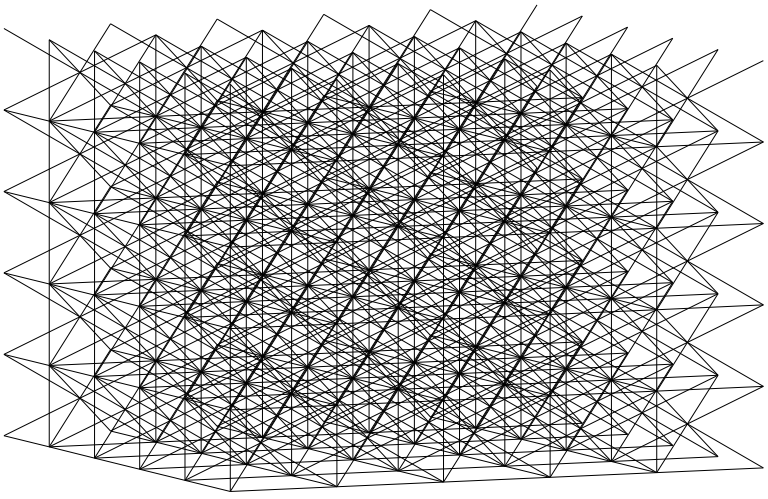
Figure 2 shows the lattice generated by the programme and one which is used for finding the percolation threshold.



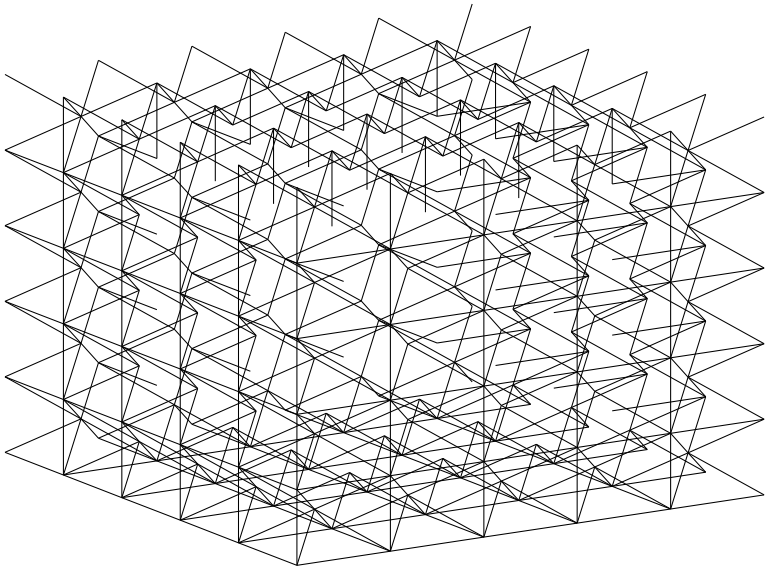
(a)



(b)



(c)



(d)

Figure 2 *Percolation of the cubic close-packed lattice;* (a) *a unit cell,* (b) *eight unit cells, one from each of the eight groups,* (c) *network of size* $5 \times 5 \times 5$ *unit cells, which is used in a simulation, and* (d) *the same network with only boundary edges drawn to make it easier to look at.*

At present the programme only finds p_v, p_e, x_v and x_e, not p_c, p_b, x_c and x_b. There may be altogether three types of cell and bond pairs, in comparison with two in the 2-d case, depending on whether the number of shared vertices required be 3, 2, or 1. For our purpose in the study of filtration, we only need to know p_v, which, when generated from a $5 \times 5 \times 5$ network as shown in Figure 2 (c), turns out to be 0.25. All the results from simulations are $p_v = 0.2501 \pm 0.0400$, $x_v = 8.0645$, $p_e = 0.1320 \pm 0.0209$, $x_e = 17.1709$, while $n_v = 341$ and $n_e = 1{,}375$.

This means that when the space will be blocked, *i.e.* percolates, when it is filled up to one quarter of its volume by suspended particles in the form of clusters of the highest packing density. Because the cubic close-packed spheres fill 0.74 of the space, this ratio translates into the real volume ratio of $0.74 \times 0.25 = 0.185$, that is 18.5 per cent by volume. If the fluid in our system is water, then $\rho = 1{,}000\ \mathrm{kg \cdot m^{-3}}$ and the percentage by volume above is equivalent to a density of the suspended particles of $555\ \mathrm{kg \cdot m^{-3}}$. Notice also in our simulation that the cluster shapes need not be convex.

In the light of the symmetry between particles and space, in other words between particles and anti-particles, which give rise to a symmetry and the three types operational regions that I originally proposed in a study of traffic congestion (*cf* Tiyapan, 2004), the operational space of our filter may fall into three distinct regions when it is subjected to very small particles suspended in a fluid.

If we specify by ρ_v the ratio of the volume occupied by all the clusters to the total volume, and ρ the density in weight per volume, and if the three regions of operation are labelled I, II and III, then in the case of I, $0 \leq \rho_v < 0.25$, while for II, $0.25 \leq \rho_v < 0.75$ and for III, $0.75 \leq \rho_v \leq 1$. In other words, for I, II and III, we have respectively $0 \leq \rho < 555$, $555 \leq \rho < 1,665$ and $1,665 \leq \rho \leq 2,220$, where the unit of ρ is kilogram per cubic metre. Generalising this, the regions I, II and III correspond respectively to $0 \leq \rho < \rho_{c_1} = \rho_1$, $\rho_1 \leq \rho < \rho_{c_2} = \rho_2$ and $\rho_2 \leq \rho < \rho_c$, where ρ_c is determined by a physical constraint, namely the packing efficiency mentioned.

Qualitatively speaking, these three regions may correspond to the operational-, blocked and non-operational regions. If our system also contains other particles which are larger than the pores, then in Region I filters will operate normally until the effects of blocking or blinding by the large particles become prominent, as has been studied in literature (*cf* Jackson, 1994; Jafferali, 1995). In this case fouling of the filter is caused exclusively by the blocking or blinding of these larger particles, which result in the formation of cake, and unless $\rho = 0$ there will be some blockages of internal pores due to the blockage caused by small suspended particles forming cluster. This latter type of blockage, which is of our concern, is to be expected due to various reasons. Cluster formation may be caused by nonhomogeneity in the concentration of the suspension which raises the concentration in some region such that it exceeds ρ_1.

Additional reduction in the flux is to be expected from two reasons. Firstly blocking clusters may block some of the pores. And secondly, the suspended particles together with free clusters, *i.e.* those which are smaller than they could block pores, displace the volume of the liquid surrounding them and thereby reduce the flux. The first one of these will produce an effect similar to blinding described in literature (*cf* Jackson, 1994; Jafferali, 1995, *ibid.*), where no backflushing may recover the filters to their virginal state. On the other hand, the majority of those particles and clusters in the second scenario is expected to be easily removed when backflushed. Among these latter there could yet be some which adhere themselves to the walls, whose fixation defies backflush-

ing. But these last ones are expected to be small in number, and thus can be neglected, because we shall assume that the combination of ρ and channelling results in the probability that pores are blocked being very close to either zero or one.

The channelling effect, or the occurrence of rivulets by some other authors, is the formation of preferred paths through a porous media through which liquid and the solids it contains pass. It is not yet clear what these rivulets would do to our system. If all the channels channel equally both the liquid and the solids, then the blockage along these path may be expected to rise above the average value of the whole structure if only because this becomes more probable statistically. But if there exist some channels which prefer channelling liquid to particles or vice versa, then the effect they produce will vary and become complicated. For example, channels which like to channel particles are more likely to find themselves blocked in the end by those particles which pass through them. On the other hand those channels which channel liquid better than solids will be less prone to blocking on average, but will leave other pores around them with the excess particles, and these latter will necessarily become blocked more often than usual. But, for our purpose here, we shall assume that it is solid particles that are being channelled. This should raise the possibility of blocking in some of the pores by certain amount. Channelling in general needs further investigation which will not be covered here.

Before going on to the next step of our study we should briefly look at the core idea that makes the programme used. There are eight types of unit blocks here, compared with the four types in the case of the programme listed at the end. These correspond to the area drawn and labelled in Figure 3.

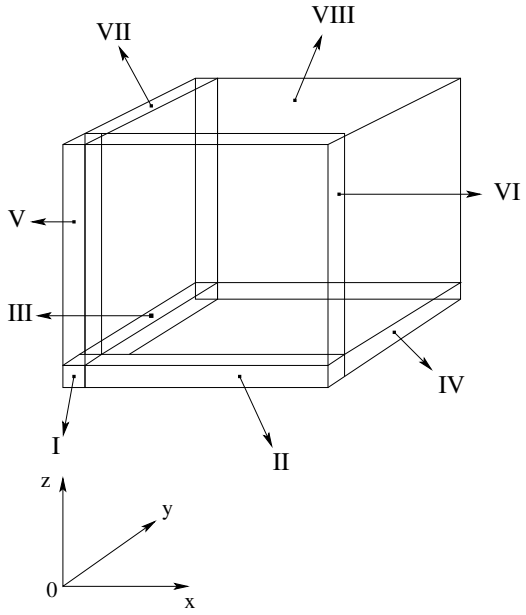


Figure 3 *The eight areas defined by the eight types of unit blocks*

Figure 3 shows the eight areas defined by the eight types of unit blocks they contain. Area's from I to IV correspond to those previously defined for the 2-d programme. Although unit blocks in the various areas works differently, that is to say, they adopts different set of vertices from different sources, and create different edges, all of them follow the same four rules. These four rules in the mnemonic not cryptic forms which I use are, *take vertices from behind*, *make front vertices*, *draw edges behind* and *draw no front edges*. With these rules in mind, both programmes should become self-illuminating to such extent that no further explanation is needed. This set of rules does two things, namely organise vertices and then link them with bonds. The unit vectors in the three directions being orthogonal means that we will have a nice and square end product suitable for a percolation study.:

In fact it is wrong to say that all four rules work differently for each unit group. Only the two on vertices, *viz.* the first two, are different. The rest, *viz.* the last two which concern edges, are the same for all basic units. These are the only two crucial tasks with the discovery of

which the writing of both programme becomes worthwhile.

The input data needs only contain details regarding units in Area II, III and V. Area I, being at the origin, is trivial, or should one rather say unique. Area IV can be derived from Area's II and III. Like wise VI is derived from II and V, and VII from III and V. Finally Area VIII turns out to be nothing but II, III and V combined.

So far we have only mentioned the situation where $0 \leq \rho < \rho_1$. In the second case, where $\rho_1 \leq \rho < \rho_2$, many more pores are blocked from small particles than in the first case. The concentration is already beyond the first critical point. But while the second critical point is still not reached, there would still be an infinite cluster of space – in this case the liquid – surrounding the particles. In other words the space still percolates. The presence of this infinite cluster, or continuum of the medium, means that the filter can still be in operation until it should be blocked or blinded by larger particles which individually can physically block the pores as found in existing literature earlier mentioned.

The third and last case, where $\rho_2 \leq \rho \leq \rho_c$, represents the extreme which can be easily comprehended. Here the solid particles occupy more space than the liquid does, as a result of which the combination is no longer a suspension but a slurry. Clay material produced by this slurry would block most of the pores within the structure and make filtration impossible. Backflushing will not be effective on filters which have undergone such fate.

The second part, flow through the cells

Next we will investigate briefly the effect that channelling may have on the value of p_c. There are three cases considered here. The programme for this purpose is listed in Tiyapan (2004). The programme creates a centroidal Voronoi tessellation in three dimensions. The first set of simulations works on a normal case of cell percolation, similar to that used by Tiyapan (2004) but here the system is a centroidal Voronoi, which implies a constraint on cell sizes and distribution. The function `perd` in it is obtained by inputting the `Blocked` variable instead of generating it internally.

This section is written along with my developing the programmes, so the contents should be easier to follow than in other sections. This is not to say that in those other sections I had not kept records of things discovered. Every Ph.D. student starts off doing his project knowing

that he should write along as he goes, and plans to nothing but that. But the truth is that even though we always write, but the way we write develops with our experience. Also, with the increase in the understanding of our problem, we no doubt would be able to write a better description of what we do and how we do it. This is unavoidable, and it is probably the reason why we should keep on working.

So much for an aside. From one hundred generators originally, Voronoi operator is applied twice. After the rims has been trimmed there are 280 centroidal Voronoi cells remaining, and this is the value of n_c. For x_c the value is 10.7929, while p_c from 2×5 simulations is 0.2314 ± 0.0602.

Next investigate the effect of channelling by assuming that the steepest gradient of all the bonds arriving at a cell decides how quick it percolates. Here cells are sorted according to their steepest gradient of incoming bonds. Working on the same network as previously, if the percolating order is such that the steeper the quicker, then $p_c = 0.2107$. But if on the other hand steeper incoming bond means slower percolation, then $p_c = 0.1429$. The critical probability is constant in this case since the order of percolation is predetermined by the orientation of bonds with respect to cells.

If instead of looking at only a single bond we take the signed summation of bonds entering and leaving a cell, then $p_c = 0.1321$ when the criterion is $\min(\sum b_i - \sum b_o)$, and $p_c = 0.1393$ when it is $\max(\sum b_i - \sum b_o)$, where b_i and b_o are respectively the incoming and outgoing bonds.

Our studies up to now tell us that if the suspension is homogeneous and there is a rivuleting effect, then the location of the blockages made by clusters of suspended particles among all pores of the structure is predetermined. This is in contrast with the blinding and blocking of large particles, where such location is random. In fact, even for these latter large particles, the location can only be random when the particles have a variety of sizes. It can never be wholly random, however, if this is not the case, since in the former case the randomness is introduced by the distribution of sizes which is random, but in the latter the blinding or blocking will be determined by the size of pore openings which is fixed by the geometry of each network. The randomness then can only be in the order not location of blockings.

The next study is a combination between continuum and network percolations. Here suspended particles are grouped into quanta, each channelling through a path or rivulet of interstitial distance with some

interstitial velocity.

At the top, the layer of the structure where the incoming particles arrive, is a cross section all the cells of which are gridded to provide means to determine the path at the beginning of each quantum. The partitions in this layer is conveniently found by cutting some faces of the convex hull of each cell in the top layer by the plane $z = 0.9z_{\max}$, where $z_{\max}$ is the maximum z-coordinate of all the cells under consideration.

Given coordinates of two points, (x_1, y_1, z_1) and (x_2, y_2, z_2), and a plane equation $z - a = 0$, we may think of the plane equation as being one coordinate given, $z = a$, and find the coordinates of intersection between a line passing through the two points and the plane from the parametric equations for the line. Parametric equations are in fact interpolation done on each of the coordinates. In this case, which is useful when finding the intersection between an edge of a triangle and a plane perpendicular to some coordinate axis, the parametric equations are $x = x_1 + x_{12}t$, $y = y_1 + y_{12}t$ and $z = z_1 + z_{12}t$. From the plane equation $z = a$, therefore

$$t = (a - z_1)/z_{12} = (a - z_1)/(z_2 - z_1)$$

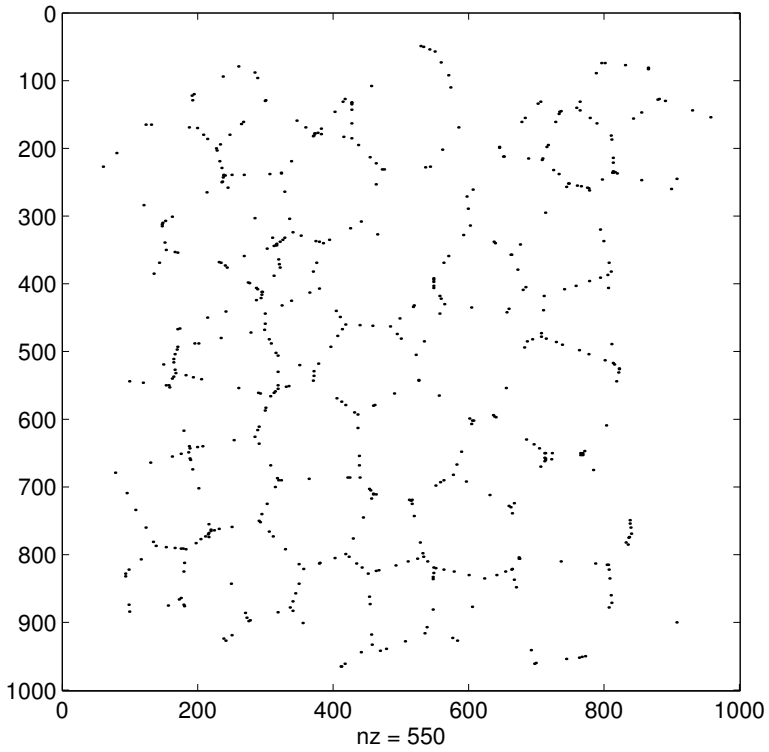


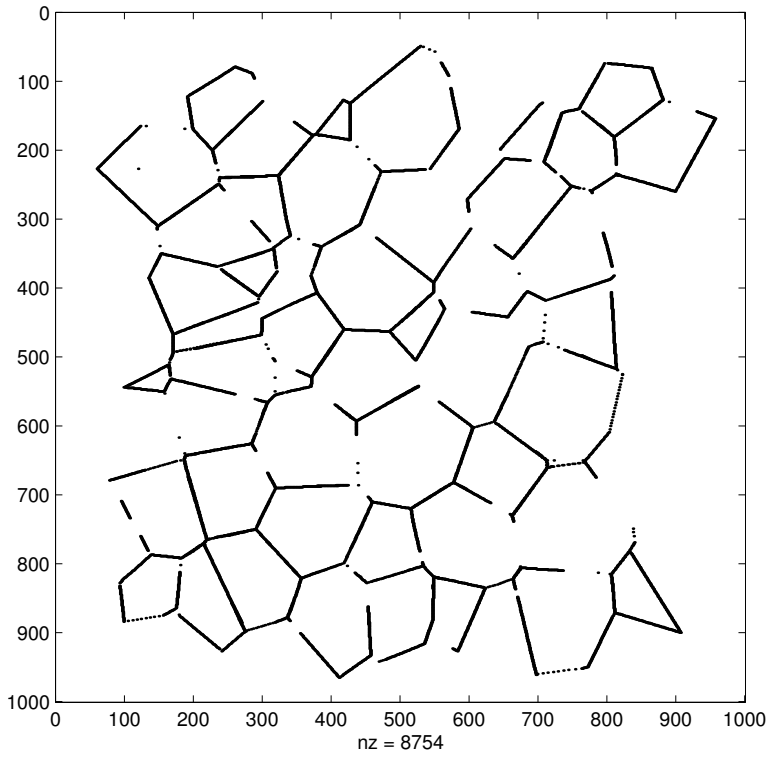
Figure 4 *Intersection of convex hull faces and the horizontal plane*

The programme being written finds the intersection of cells with the horizontal plane by finding the intersection of the faces of its convex hull with the same. Since every face of the convex hull is a triangle, the programme essentially finds intersection between edges of these triangles and the horizontal plane. The result obtained from an intermediate state during the course of development of the programme is shown in Figure 4. The partitions look incomplete because the picture is taken as a test while developing the programme as mentioned. A picture with the same degree of incompleteness as this one is not to be obtainable from the completed programme.

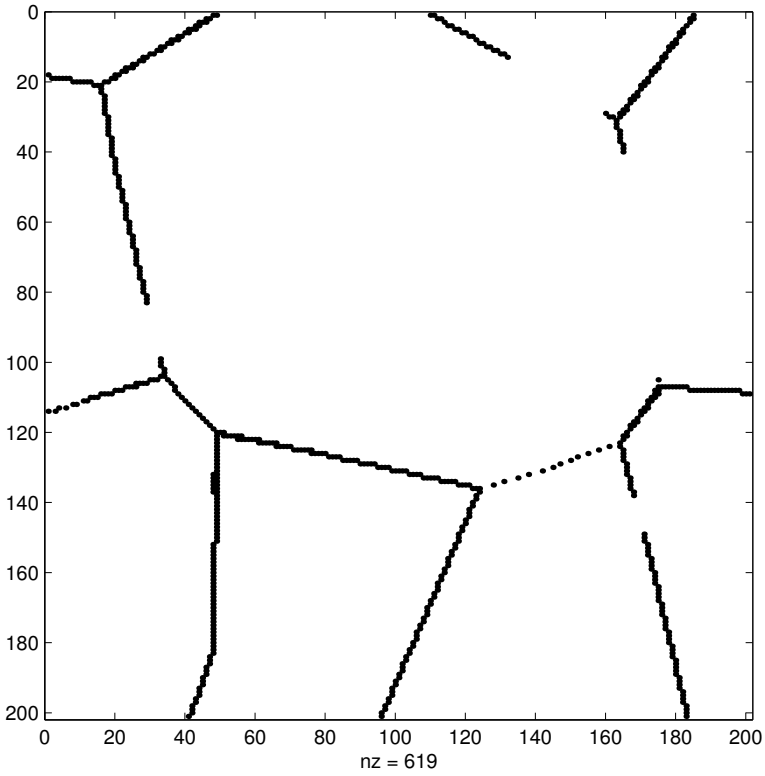
For each face of the convex hull that intersects the plane, there will be two points of intersection arising from the two edges of the triangle intersecting it. Let (x_1, y_1) and (x_2, y_2) represent these two points. Then we may scan up in the y direction finding $x = x_1 + (y - y_1)x_{12}/y_{12}$ for each y along the way, and then scan in the x direction, this time finding instead $y = y_1 + (x - x_1)y_{12}/x_{12}$. Afterwards we could fill in the space

by scanning along the x direction for all y positions.

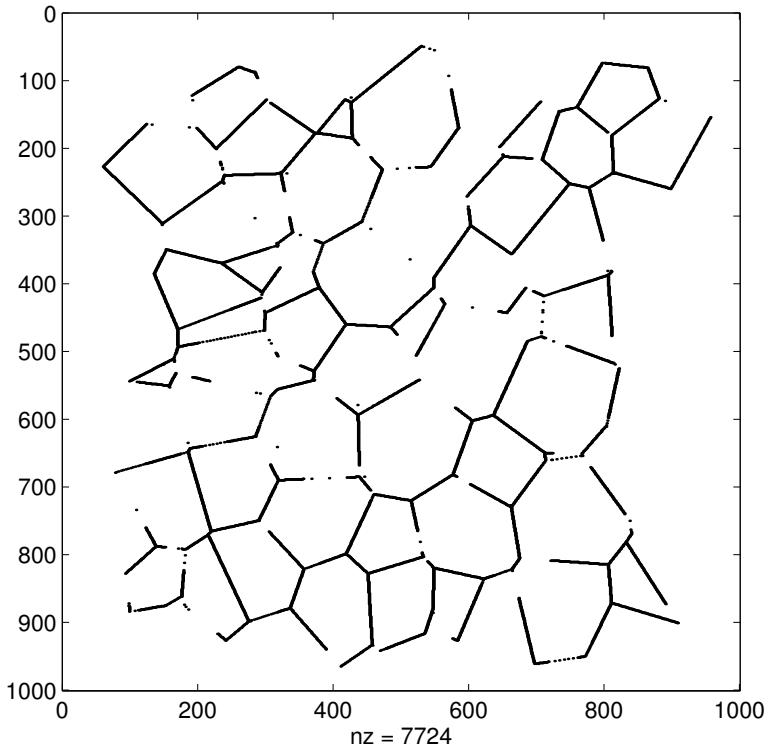
Figure 5 shows the progress of my programming the codes, step by step, trying to close all the partitions such that no gaps remain. Two problems have been discovered, namely those of rounding and precision. Before the correction the result looks like Figure 5 (a) and (b), and after rounding problem corrected Figure 5 (c).



(a)


0
20
40
60
80
100
120
140
160
180
200
0 20 40 60 80 100 120 140 160 180 200
nz = 619

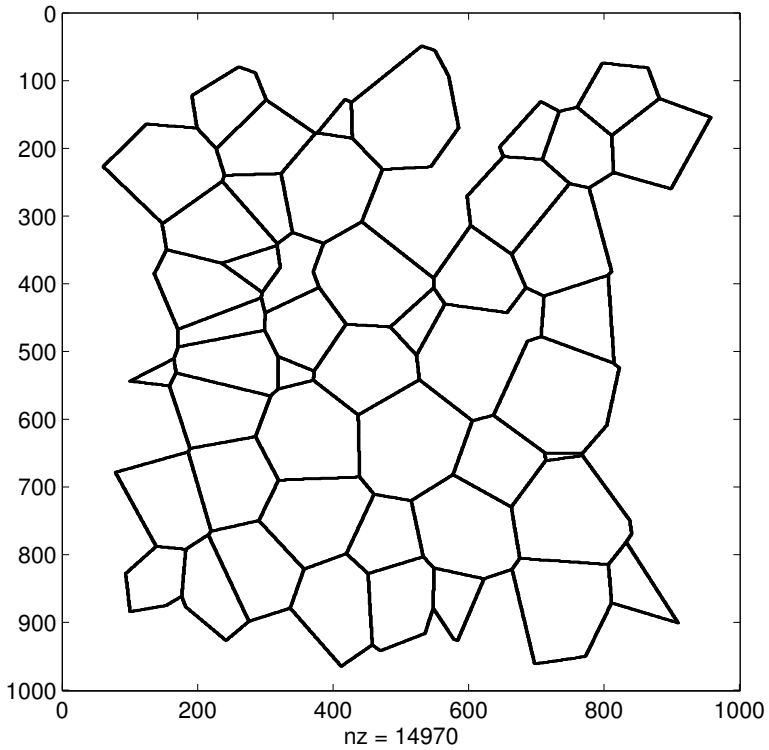
(b)



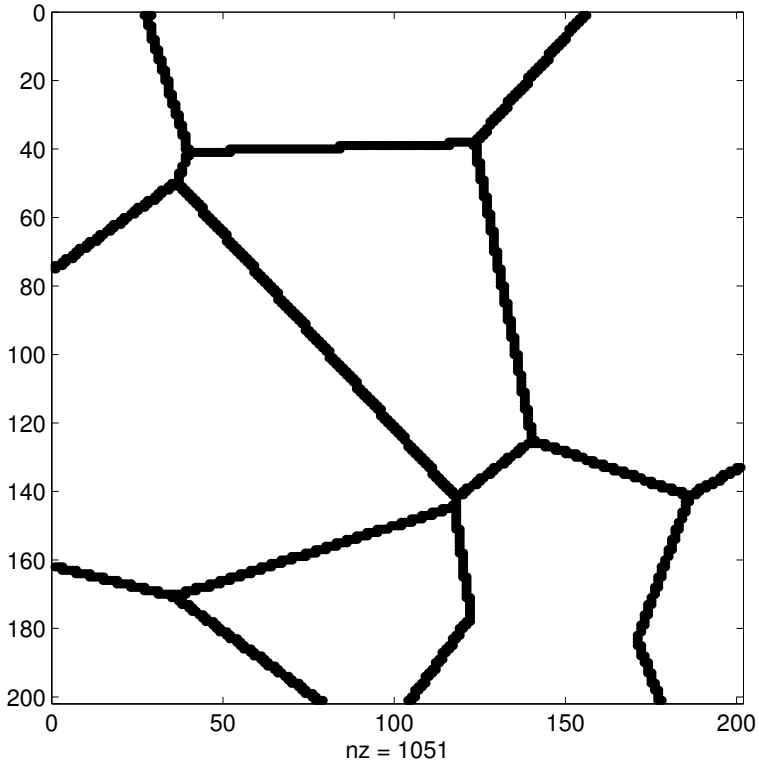
(c)

Figure 5 *Correcting the effect of rounding, in other word discretisation.* (a) *The gaps resulted from rounding or discretisation,* (b) *a closed-up view of (a) and* (c) *partial remedy where roundings have been solved but with the degree of precision not yet raised.*

After having corrected the problem regarding precision, by increasing the number of steps when calculating x or y, the result still misses several walls, the cause of which is still unknown at present. This is shown in Figure 6.


0
100
200
300
400
500
600
700
800
900
1000
0
200
400
600
800
1000
nz = 14970

(a)



(b)

Figure 6 *After having increased the precision to ten times the previous value,* (a) *and a closed-up view,* (b).

It seemed at first that there might be some triangular faces missing from the surface of the convex hull, which would have accounted for the missing boundary in the section. But after having tested the minimum number that an edge of each hull appears as the edges of all its triangular faces, and see that it's value is correctly two, this becomes out of question.

The figures, *viz.* Figure 4, 5 and 6, are produced from the `spy` command in Matlab, as a result of which the x-axis runs downwards while the y-axis runs to the right. This command looks at a matrix from above as we look at a map. In the present case our matrix is a full-, not sparse matrix. The number written at the bottom is the number of all its nonzero components, which is less than the number of times that we calculate them since we need to calculate some of the points more

than once in order to increase the precision to eliminate gaps in other places.

The command `spy` is used more often with sparse matrices since these are often too large to list, and listing their members in pairs makes it difficult to visualise. As an example, Figure 7 (a) is what we get when we `spy` our neighbour matrix `necc`, while in Figure 7 (b) are all the neighbours that the 100^{th} cell has. Cells which have few neighbours generally live along the border. For example the 110^{th} cell has only three neighbours, and it is located not far from the lower x limit.

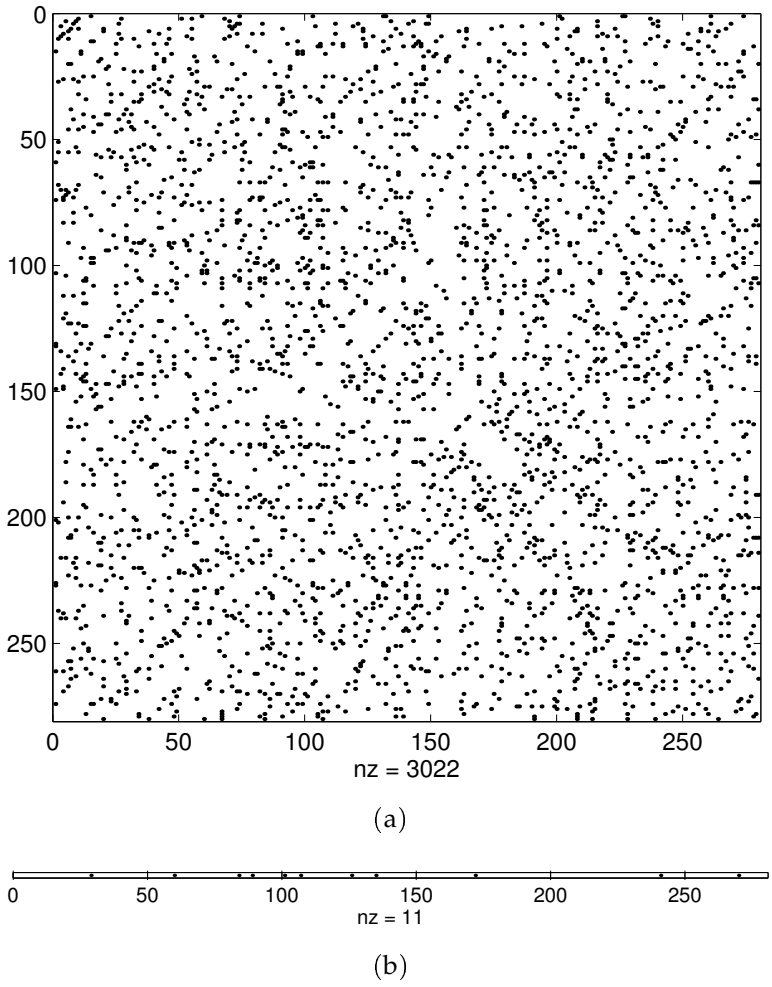


Figure 7 *The result when we* `spy` *our neighbour matrix. Here* (a) *shows the neighbours of every cells while* (b) *only shows those of the* 100^{th} *cell.*

At this stage the neighbour matrix of the programme is double-checked, and find that it includes poorly defined neighbours, that is those which only have one vertex in common. Therefore the programme is first altered to make it only look for neighbours who share at least two vertices. But this has shown no noticeable changes in the results that we have so far.

The next step is to colour the cells. Like a child painting a picture, there are so many ways one can paint or label the tiles of a tessellation. For example one could draw a vertical line first and then branch out either horizontally or diagonally. On the other hand, one could also draw the diagonals first. Yet another way is to expand radially, spiralling outwards. With parallel computing we could also divide the area into domains, paint each domain, and then merge the resulted areas together.

But here we opt for painting the cells by scanning horizontally, moving upwards in layers. Once past a wall, the programme moves on until the next wall is reached while gathering all the grids that are between the two walls into one group. It then colour the whole group by a colour picked up from one layer below it. If no colours exist, then it creates a new colour which in turn gradually propagates upwards this way until the upper wall is reached.

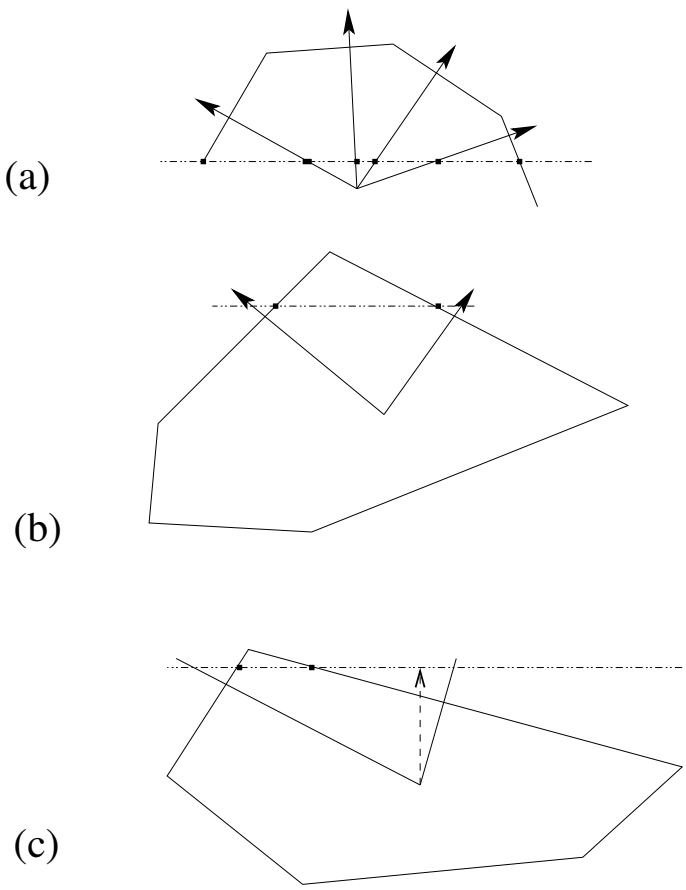


Figure 8 *Sections of bonds and cells*

The intersection of bonds will not always coincide with the intersection of the cell, neither is the projection of a cell perpendicular to the plane the sectional plane of the cell. This is because of the three possible situations shown in Figure 8. In Figure 8 (a) the cell section contains several points, while both (b) and (c) contain none.

And here sadly the time runs out, so I will suffice myself to describing what I see should be done next. Up to now we have a three-dimensional network and its top section. We also have the list of all its

bonds, which contains the connections and the draining angles sorted in a descending order.

Next we should find a mapping from each cell section to the corresponding nuclei. Then the times it takes to traverse each bond must be calculated. This time for each bond is then divided by half, one belonging to each of the two cells connected by the bond.

When it comes to bombarding the filter with our small particles, we can not keep track of millions of particles and therefore we should quantise them into units. These units or quanta can then be treated as individual particles. When a quantum enters a cell, it is assigned t, the time to reach the nucleus. Later time sees this t decreases in steps until it finally reaches its destination, the nucleus. Once there, it is assigned the next bond to go along, taking into account what bonds are available at the time and their comparative probabilities, which in turn depend on their gradient as mentioned. When this is decided, it is given t_1, the time it would take to reach the border that lies at mid point of the bond.

This goes on forever, apart from that at each time step we look to see whether the blockages in our filter has percolated. After updating the list of blocked cells, if we find that percolation has occurred then the simulation would end. Percolation occurs in each cell whenever its concentration has reached a certain value. This value we have found to be 18.5 per cent by volume.

To calculate the flux decrease we find instead the decrease in the superficial area. This is calculated from the total volume of the void subtracted by the volume of all cells that had percolated, and then subtracted by the total volume of solid particles which are suspended inside the network. The area of the cross section is then the volume which remains divided by the thickness of the filter.

It is not a little to have to leave things unfinished after having started it off. But as one New Zealander poet says, 'Alone we are born and die alone, yet see the red-gold cirrus over the snow mountains shines. Upon the up-land road ride easy, stranger. Surrender to the sky your heart of anger.' And with this we go on to the next chapter.

To summarise, we have begun our study from the Voronoi network, and then went on to study continua and then tried to combine them together. I have suggested the idea that a percolation in continua

can be represented by a percolation in a lattices the type of which depends on the attrition mechanism of the particles in that continuum, in other words the way they pack together.

Bibliography

N. M. Jackson. *A mathematical model to simulate the structure and performance of porous media.* PhD Thesis. UMIST, Manchester, 1994.

Riaz Jafferali. *A stochastic model to simulate the structure and performance of microfiltration media and the growth of animal cell cultures.* PhD Thesis. UMIST, Manchester, 1995.

K Tiyapan. Modelling of traffic congestion. submitted to the Journal of Statistical Physics. 4^{th} November 1997 .

K N Tiyapan. *Percolation within percolation and Voronoi Tessellation.* Kittix, Bangkok, 2003

K N Tiyapan. Division of space by Voronoi graphs, percolation within percolation and application to the models of porous membranes. *Ph.D. Thesis.* University of Manchester, 2004

Bhavati

Kit Tyabandha, Ph.D.

Dieu, Existence, God, Sacca and Truth are one and the same. Thus I call 'godless' a language which has no concepts of existence. Daiï is one such language, as so are most of the Eastern languages. It seems the existence of this concept only exists in Indo-European languages.

To the list of these words which mean God I add a new word Ðiaö for Daiï. Thus the equivalence goes, 'One God' in English, 'Un Dieu' in French and 'An Ðiaö' in Daiï Each of these has two syllables, and so is the case with Hebrew 'Yahweh.'

For the word 'to exist' or 'existence' I add a new word in Daiï, 'bhavati', which is in fact a Pali infinitive for 'to exist'.

The concept of existence is so important it plays a key role in Philosophy, Mathematics and Literature. In the latter *Hamlet*'s 'to be or not to be' had been translated into Chinese as 'to live or to die', the doing of which would have turned Hamlet into a perfect comedy! But Hamlet is unarguably a tragedy, and 'to be or not to be' has to do with existence and free will, thus it is everything whereas 'to live or to die' only has to do with earthly survival, therefore it is nothing. Translating that phrase this way amounts to translating everything into nothing, which is nonsense to say the least.

All tragedies are about a question of existence. In *Macbeth* this appears as, for instance, 'and nothing is but what is not.'

It is impossible to do philosophy without a concept of existence. A philosopher is one who asks himself questions about existence. Buddha spent his whole life seeking after Sacca (Truth). In the process of doing so he asked a whole lot of existence questions, Death, Diseases and Birth. In the same way as Love with a capital L, Death with a capital D means the existence of death. Buddha was no physician. He was not interested in the process of birth, illnesses and death. He wanted to know why there should exist birth, sickness and birth.

Nothing may escape Existence. Even when we talk about a non-existence, Nullity, or Sūñatå., we can only do so because the existence

of that non-existence, Sūñatå, and so on.

In Mathematics you definitely need a concept of existence. It is impossible to do mathematics without that concept. With the word 'bhavati' for 'to exist' we now could say in Daiï our first theorem of Calculus, the theorem of limit.

$$\lim_{x \to a} f(x) = L$$

gụe, thạ̀ hàị̀ $\epsilon > 0$ dị̀ $f(x) - L < epn$, lãeö bhavati δ dị̀ $0 < |x - a| < \delta$.

'Bhavati δ' neither means 'ca sạmạrth hạ δ' nor 'mị̀ δ.' For one thing, 'mị̀' is 'to have' and could never be translated into 'there is.' Here one needs to find no actual δ's. This is similar to in geometry where, 'through any point there exist an infinite number of lines.' A point has no dimensions, a line has one dimension only. It is impossible to *find* any one of these. There is a difference between a dot and a point. The latter only exists as a definition.